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Achievements and Problems in Fertilizer Chemistry.

An indication of the marvelous rate at which the commercial importance of the artificial fertilizer industry is increasing from year to year, is the equally marvelous increase of chemical research activity now centered on problems of fertilizer chemistry. In our last few issues we published quite a number of interesting papers presented before the International Congress of Applied Chemistry reflecting both achievements and hopes of energetic workers in this field.

The three papers by Dr. Eyde, Dr. Bernthsen, and Dr. Palmaer, which were published in our issue of September 12th, reported actual achievements. Dr. Eyde's paper on the engineering and commercial success of the Baekeland-Eyde process for making nitrates from atmospheric nitrogen was a wonderful story of the creation of a new and very important Norwegian industry, built up by Norwegians and limited to Norway and such other countries as are favored in an equal way with exceedingly cheap abundant hydroelectric power. The product is calcium nitrate or "Norsk saltpeter."

Dr. Bernthsen's paper was an equally wonderful story, how through German energy the synthesis of ammonia has been accomplished. The Badische Company has sold out to Dr. Eyde its interest in the Norwegian nitrate works and is concentrating its efforts on ammonia. From the nature of the process its application is hardly limited to any country.

Dr. Palmaer's interesting paper on his method of producing bicalcic phosphate fertilizers with the aid of electrically produced acid and alkali also records an accomplished fact since the process is in commercial operation in Trollhattan, Sweden. The process would seem to have promising prospects on this side of the Atlantic especially for the phosphate deposits in Canada and in Virginia.

In the present issue we publish a series of congress papers all written by American chemists and all dealing with the burning problem of the possibilities of an American potash industry. The object is to get independent of the German potash monopoly. There are many possibilities, but most of the papers record chiefly the hopes of the inventors. Undoubtedly Dr. Cushman has gone furthest in his large-scale experiments. What has so far been accomplished is certainly encouraging, and the object is worth the work that is spent on it.

"Juicing In."

In any new art or in any new science, it is of considerable importance to have framed up a new set of words, precise and definite in their meaning, to apply to new forms of apparatus and operations or reactions. The scientific world owes a no mean debt to Michael Faraday for his foresight in asking the advice of an eminent philologist and making fit the terms electrode and ion, anode and anion, cathode and cation, diamagnetic and paramagnetic. These words are definite and by their

derivation connote their own particular functions and properties. These words have been invaluable to the cause of science.

It seems now apropos to discuss some new terms for two operations of the electric smelting furnace. When an electric furnace is started up for the first time it seems disconcerting to say that the furnace is "blown in." The electric furnace engineer is entitled to his own jargon and in actual practice we have heard him avail himself of the term so familiar to all classes of the electrical world, "juice," and coin the verb "juice in" or "juice on." Thus it might be said that the U. S. Steel Corporation "juiced in" its first Heroult furnace in 1909.

When a coal or coke furnace is "banked" or "on dead fire" it is kept at a heat by a gentle blast slightly below the operating temperature in a condition ready to be started again, when desired. Similarly another phrase might be coined and an electric furnace said to be "on dead-juice" when it is kept by the use of a small amount of electrical energy in a constant available metallurgical condition.

These terms have been used in actual practice; they are proposed here tentatively as to their availability for more general use and we wish that our readers who can, would give the electrometallurgical world through our columns any suggestions and comments on this subject of practical nomenclature.

San Francisco, 1915.

All the national engineering and scientific societies are likely to decide to hold a meeting in San Francisco at one or the other time in 1905 during the Panama-Pacific Exposition. This will be very gratifying as it will permit an almost unprecedented opportunity for an exchange of ideas, if properly organized. But if this organization is not perfected long in advance, these meetings are likely to be held, as we said, "at one or the other time" of the year. This is the point to which we wish emphatically to draw the attention of those interested in the success of the meetings to come.

The two largest congresses in course of organization and of especial interest to our readers are the International Engineering Congress and the International Electrical Congress. The International Engineering Congress is being organized under the auspices of the American Society of Civil Engineers, the American Institute of Mining Engineers, the American Society of Mechanical Engineers, the American Institute of Electrical Engineers, and the American Society of Naval Architects and Marine Engineers. This is perhaps "representative" enough, although we do not think so, chemistry being wholly unrepresented. An International Engineering Congress to become a real success should be organized on the broadest possible foundation. But this is aside the point we wish to make here.

The organization of the International Electrical Congress is well under way and it is hoped to make it a worthy successor of the congress held at the time of the St. Louis World's Fair in 1904. The fear has been expressed that one of the two congresses might overshadow the other, and that the result would be detrimental to both. This will certainly be the case if on account of the fear of being overshadowed the decision should be reached to hold the two congresses at different times of the season, as this would necessarily impair the attendance at one or the other occasion or both.

The chemical societies have not yet made any arrangements for 1915 with the exception of the American Electrochemical Society which has accepted in principle, through its Board of Directors, an invitation to meet in San Francisco in 1915. But, of course, no date has yet been fixed. It will be logical for the American Electrochemical Society to meet jointly or at least simultaneously with one of the above named big congresses. But which one should they choose if the congresses were held at dates far apart? In the same dilemma many other individuals and societies would be found.

Clearly this matter of fixing the dates is of first importance for the final success and those responsible for the reorganization of the two congresses should decide to come together as soon as possible. It will not be necessary to set exactly the same dates for the two congresses. They may be made to overlap or to follow each other, but in fixing the dates the interrelated interests of all must be taken into account.

Past experience proves that it is not too early now to have the importance of this matter properly fixed in the minds of those who will be held responsible in 1915.

Modification of Vacuum Filtration

The records of the Patent Office usually are dry, prosaic and matter-of-fact, and unlikely to be of broad general interest. And yet, when regularly perused over a long period of time, they reveal peculiar qualities of human nature. To illustrate: Let any inventor conceive an original, fundamental idea, and make it public through the Patent Office. Straightway, a score of modifications of the invention will appear, perhaps showing improvement in some detail which did not occur to the original inventor, but more particularly revealing the variety of forms which the same suggestion will assume in different minds. The record tells a story of a few original conceptions and many modifications or adaptations; of a few minds that did the suggesting and of many more which needed the merest hint in order to bring out a dormant idea. It would be unfair to assume that the latter class are only copiers, for often their modifications carry the original idea to a more logical conclusion, and give it a more useful form.

Since Moore first applied a vacuum to the filtration of ore-slime in the cyanide process, numerous changes have been proposed in the form of apparatus embodying the invention. Some of these have been eminently successful because they met conditions which were not anticipated by the original inventor; others have not yet had an opportunity to prove their worth. Moore's unit was a number of leaf filters which he moved from tank to tank in order to go through the cycle of filtration. This was modified by Butters who kept the filters stationary and pumped the various solutions to and from the filter tank. Ridgway went a step further, making a continuous process by causing the units to travel in a circular path through a succession of tanks containing the different solutions. Thus we find at least three modifications of the "basket" type of vacuum filter.

Later we find a different modification in which the filtering surface is placed on the peripheral surface of a large drum, giving the continuous "drum" type of filter as in the Oliver and Portland. This form has also been modified by a proposal to filter from both the outer and inner surfaces of the drum.

The horizontal table type is still another modification which, however, has not yet been widely used. Caldecott has applied

the principle to dewatering sand, and several American metallurgists have embodied the idea in machines for slime filtration. In this form the filter units are arranged as segments in a revolving round table, giving continuous operation as in the drum machines.

Recently the patent records have disclosed a new modification which for want of a better designation might be described as the "wheel" type of filter. One of these was noted in our last issue, and two more are described in our columns this month. Essentially this type is a series of wheels mounted on a shaft, and revolving in a tank such as is used with the drum filters. The filtering members are leaves placed between the spokes of the wheel as in the horizontal table type. In one case the inventor proposes to perform the several operations of a cycle by pumping the different solutions to and from the filter box while the leaves revolve through it making a sort of continuous Butters filter. In another the characteristics of the Moore are retained.

Thus the variety of vacuum filters is almost kaleidoscopic, and yet all are so closely related in essential principles that only general distinctions can be made. Up to the present time only the basket and drum types have been widely adopted; whether the table and wheel types will gain further prominence depends on several factors which experience alone will develop.

The Metallurgist in Steel.

While it is not conceivable that the mechanical engineer should ever come to occupy a subsidiary position in the manufacture of steel, it is distinctly a development of the times that the metallurgist is coming more into his own. One cannot lose sight of the fact that in the mad rush for increased tonnages in steel production which emphatically distinguished the decade of the nineties in the development of steel manufacture the physical and chemical characteristics of the steel produced were not sufficiently regarded. It was distinctly the day of the mechanical engineer. The problem was simply to increase the tonnage. With experience has come knowledge, both to the producer and to the user, and the burden to-day is upon the metallurgist.

Witness, for instance, the very prominent place which the problem of producing sound ingots occupied at the Leeds meeting of the British Iron and Steel Institute, as noticed in the report in this issue. This is purely a metallurgical problem, although in solving it upon a commercial basis engineering skill is necessarily brought into requisition. It is, however, not easy for one who reads the very able and interesting papers and discussions at the Leeds meeting to determine what is metallurgy and what is engineering in the matter presented. Perhaps it is too fine a distinction, or rather a distinction which should not be made at all in this form. There is coming into his own at present not so much the metallurgist as such, but the combination of the metallurgist with the mechanical engineer. The ideal is, of course, to have this combination realized in a single man—the metallurgical engineer. Though as long as "metallurgical engineers" in this sense are rare, we must rely on a hearty co-operation between the two individuals representing metallurgy and mechanical engineering respectively. And in this respect we are inclined to the viewpoint that in the older days the engineer did things, regulated occasionally by the limitations which the metallurgist had discovered, whereas to-day the metallurgist takes the initiative in accomplishing better results, and is merely aided by the engineer.

As an illustration that may not be without interest, a trifle over twenty years ago Mr. John A. Potter, then superintendent of the Homestead Steel Works, patented a process for producing sound ingots, covering a process which distinctly betokened the engineer and not the metallurgist. In essence, it was to compress the ingot hydraulically when in the mold, first upon its whole head, and then, by an ingenious means, to concentrate the same total pressure by means of a relatively small piston upon the central portion of the end, the walls of the ingot having meanwhile become so thick as to withstand an enormous pressure, much greater, of course, than could have been withstood by the walls of the mold alone. This was a mechanical engineering invention, designed to exert a very great pressure upon the steel, at a relatively small expense per ton. Not enough was known at that time about the behavior of steel to know precisely what was required to produce a sound ingot, and the idea was to "try on" an enormous pressure.

At the Leeds meeting at the beginning of this month Dr. J. E. Stead described a process developed by Mr. B. Talbot which he declared was "epoch making" and which aimed to produce a sound ingot—Dr. Stead asserted it was only necessary to square off the ends in order to have an ingot sound throughout—by the application of relatively little pressure, but exerted in such a way and at such a time, through the knowledge since gained of the behavior of steel in its freezing, as to produce the desired result. First purifying the steel by the use of aluminium or silicon, Mr. Talbot quickly strips the ingot, places it in the soaking pit for a short time, and then, when the central portion is still liquid, gives the ingot a few passes in the cogging mill, enough, for instance, to reduce a 20 x 25-in. ingot down to 18 x 18 in. In the horizontal position, the liquid steel flows partly into the pipe, and the reduction entirely eliminates the pipe. This one may call a metallurgical invention, mechanical engineering being merely the handmaiden of metallurgy.

The two papers on methods of producing sound ingots, presented at the Leeds meeting by Sir Robert Hadfield and Dr. Hans Goldschmidt respectively, also emphasize the same viewpoint. Before Sir Robert Hadfield set out to devise his methods of heating the ingot from the top with an intermediate protective layer of slag, he first devised a method of studying experimentally what is really going on in an ingot during solidification. This is the procedure of the metallurgist. As to Dr. Hans Goldschmidt's new method of using his anti-piping thermit, this is very different in principle from his older method using practically the same apparatus and is far more effective. It is now essentially a mechanical stirring process pure and simple, but a mechanical stirring process making use of a chemical reaction which would never have occurred to a mechanical engineer, but which, like the whole brilliant thermit process with its numerous applications in the iron and steel industries, could be invented and carried to commercial success only by a metallurgist.

Meeting of American Iron and Steel Institute.

The convention of the American Iron and Steel Institute was opened at Pittsburgh, Pa., on October 25th. A report of the convention is reserved for our next issue.

Meeting of American Institute of Mining Engineers.

The Cleveland meeting of the American Institute of Mining Engineers, which is to last to October 31, started with an informal social meeting on the evening of Monday, October 28. The professional sessions begin on October 29. A report of the convention is reserved for our next issue.

Meeting of American Institute of Chemical Engineers.

The fifth annual meeting of the American Institute of Chemical Engineers will be held in Detroit, Mich., from December 4 to 6, 1912.

1913 Meetings of American Electrochemical Society.

The Spring meeting, 1913, of the American Electrochemical Society will be held in Atlantic City, N. J., the Fall meeting, 1913, in Denver, Colo.

The exact dates have not yet been fixed.

The Western Metallurgical Field.

The Thiogen System of Fume Control.

The effective control of smelter fume has been a problem for years commanding the attention of metallurgical engineers. With the exception of sulphur dioxide the various constituents of the fume have been controlled, but this volatile vapor has continued to defeat all attempts to completely prevent its escape. The solids carried by the smoke have yielded to mechanical means, such as the baghouse and electrical contrivances, but it has been conclusively shown that mechanical devices are unable to handle sulphur dioxide gas, and as this element is one of the principal sources of damage to vegetation, the importance of its control is appreciated by all familiar with the subject.

In the Thiogen process it is proposed not only to control the noxious gas, but to make the detrimental factor become an asset. In smelting, each 1000 tons of pyrite ore discharges approximately 800 tons of sulphur and oxygen into the atmosphere, and by employing a reducing agent to combine with the oxygen it is planned to recover the sulphur and convert it into a valuable article of commerce. It has long been known that by uniting carbon with the sulphur fume and passing the product over limestone containing iron salts the gas is decomposed and sulphur precipitated. In the Thiogen system an oil spray is used to supply the carbon, and calcium sulphide forms the suitable accelerating agent. Calcium is preferential to potassium and other alkaline sulphides because of its lower cost and high infusibility. It has been found desirable to clean the gas as thoroughly as possible and to concentrate it before it is permitted to enter the combustion chamber.

The combustion department consists of a brick checkerwork chamber. A temperature of about 800 deg. C. is maintained by means of steam-injected burners, and as the oil-spray is driven into the chamber it rapidly vaporizes and mixes with the sulphur-laden gas. From this compartment the fumes pass into the reaction chamber. This has a length of 30 ft., with width and depth of 4½ ft. Like the combustion chamber it is filled with a checkerwork of brick, with the spaces of the checkerwork nearly filled with an equal mixture of sawdust and plaster-of-paris, moistened with water containing small quantities of iron salts. Small lumps of calcium sulphide are placed in the available spaces. The sawdust burns out and the $CaSO_4$ reduces to CaS more rapidly. The mixture is very porous and, as the gas is received, shrinks to about half the space in the checkerwork. The sulphur continues on to the condensing chamber, where it is cooled and precipitated as yellow sulphur. In order to prevent the formation of arsenic, selenium or other minerals with the sulphur, should they be carried by the ore, a broad, low, slightly inclined condensing chamber is employed. Water sprays reduce the temperature of the gas and the undesirable compounds are deposited on projecting tiles provided in the chamber for the purpose. As the sulphur has a lower boiling point it continues on to the regular condensing chamber.

It has been found necessary to provide perfectly air-tight construction; otherwise the inward air pressure, caused by the heavy draft up the furnace stack, leads to air leakage, defeating the best efforts. The process is being tried at the Penn Chemical Smelter, Campo Seco, Cal., and results thus far have been encouraging. Naturally, problems have arisen that must be solved, and the engineers have not had sufficient time to make the most of the system, while the old smelter has not proven as satisfactory for the tests as desired. The hostility of the farmers to smelting has prevented the company from conducting comprehensive experiments at a more modern plant. The system is the invention of S. W. Young, professor of physical chemistry at Leland Stanford, Jr., University.

The costs attending operation of a plant of this nature are expected to be largely counterbalanced by the revenue derived from the sale of the sulphur. The present sulphur supply is obtained from sulphur wells of Louisiana and the natural deposits of Mexico, Sicily and Japan. The sulphur carried by pyritic ores is of excellent quality and an immediate market for the product is expected. In the past metallurgists have aimed largely at the control of the fumes, with scant attention paid to the value of the minerals carried off by the smoke. The great and pressing question has been the government of the fumes to an extent facilitating the operation of the smelter, and the most common practice has been the arrest of solids by the baghouse or similar devices and dilution of the gas with free air to meet the requirements of the law before transmission to the outer atmosphere. Consequently the Thiogen process marks a new and forward step. It aims not only at the extinction of noxious gasses, but also endeavors to raise the detrimental elements to the dignity of a by-product

Welfare of Employees.

It is noteworthy that the larger mining companies are paying more attention to the physical and social welfare of their employees, and that the relations between the company and the men are becoming more satisfactory. Without attempting to analyze the motives which inspire this movement on the part of the companies, the fact is being demonstrated clearly that it pays well in several ways. There are fewer accidents to pay for; prevention has been found cheaper than cure. The men are more contented; dissension is wiped out by a spirit of loyalty to the company. The best labor is retained because living conditions are made attractive and a premium put on permanent employment.

The Nevada-Douglas Copper Company of Nevada is one of the new companies to adopt the policies outlined and put them into practice. A large and well-equipped clubhouse has been erected for the employees. Thirty-five new cottages and houses of modern design have been provided for men with families.

The Homestake Company, at Lead, S. D., also has recently provided a club for employees, where they can spend their leisure hours amid good surroundings and apply themselves to the pursuit of either pleasure or profit.

The various companies in the iron mining districts of Minnesota and Michigan are paying a great deal of attention to the prevention of accidents in mills and mines, as well as providing for the comfort of their men. The generous use of guards, railings, screens and signs minimizes the possibility of preventable accidents. By adopting rules and regulations for certain

operations, and maintaining a safety-inspection committee to see that the rules are adhered to, the work is done with less risk. The scheme works well if not too complex for easy comprehension on the part of laborers who are not above the average in intelligence.

All in all, companies are learning that there is profit to all concerned if living conditions are made attractive in out-of-the-way places where comfort and refinement are all likely to receive too scant consideration.

Goldfield Consolidated.

The point of interest in the operation of the Goldfield Consolidated Mines Company, of Goldfield, Nev., is the persistence of good ore at a depth of 1300 ft. in the Grizzly Bear. This ore is showing an average value of $30 per ton and is being shipped to the smelter at Tooele, Utah. The results of the deep-level work are so encouraging that sinking is being continued to the 1400-ft. level.

On account of the delay in securing returns from the smelting ore, the monthly reports are being issued later than formerly.

During the month of August, 1912, the total production was 32,538 tons, containing $465,289, or an average of $14.30 per ton, of which 30,330 tons were milled with an average extraction of 89.31 per cent and 2208 tons were shipped of an average value of $15.26 per ton, the net recovery from all ore being $12.88 per ton. The total net realization to the company was $223,581, or $6.14 per ton.

Operating Costs.—The total cost of mining development, transportation, milling, office and general expense was $6.14 per ton, distributed as follows:

Mining, including stopping and development	$3.30
Transportation	.11
Milling	1.80
Marketing	.05
General expense	0.28
Bullion tax	0.03
Marketing ore shipped	0.53
Total cost of operation	$6.16
Miscellaneous earnings	0.02
Net cost per ton	$6.14

The Iron and Steel Market.

The iron and steel market has gained so much in strength that serious fears are now entertained for the continuance of the market movement beyond the period for which the mills are already filled up. The history of the market has been one of little else than ups and downs, and when an upward movement has run its course a reversal is regarded as almost inevitable, so that the desideratum, now that a fairly profitable price level has been established, is one of but slowly advancing prices. Advances in the past three months have not discouraged buying, but have rather encouraged the movement, and the large interests are now strongly committed to a policy of holding prices where they are, and of refraining from selling for very far forward delivery.

In several finished steel products, perhaps the majority, the volume of specifications lately booked is decidedly uncomfortable, as these specifications are upon contracts well below the present open prices, and they have been filed in such a volume as to make it certain that the mills will have to carry much of the tonnage over into the new year. During the late days of September and the fore part of October specifications reached the mills at a rate far exceeding the concurrent shipments, and while at the close of October the rate of specifying is somewhat diminished—probably due to the expiration of some important contracts October 1—the specifications are still in excess of shipments. Probably a fair estimate would be that outside of wire products and tubular goods the mills will carry over January 1st not far from three months of work, in actual specifications. Naturally enough, perhaps, the mills are prone to forget how eagerly they sought business a year ago at the lowest prices prevailing for a dozen years, and far lower than the record low prices, in relation to wages and the cost of materials, and in their changed attitude they are regretting that contracts at intermediate prices were written on such a scale that the business has banked up on them, when with less laxity a goodly portion of the tonnage might have been secured at the present more remunerative prices. Since the low point, almost a twelvemonth ago, finished steel prices have advanced an average of between $6 and $6.50 per net ton, but the average invoice price of shipments being made to-day by the large mills is probably no more than $3 a ton above the low point. With the smaller mills, which as a rule do not make contracts, the average realized price is naturally much higher, and beyond this is the fact that the smaller mills are now able to realize upon a large part of their shipments, not merely the present openly quoted prices which are regarded as "the market," but much higher prices, due to the charging of premiums. Such premiums in the case of merchant steel bars and plates, are ranging from $2 to $4 a ton above the regular market prices of 1.40 cents on bars and 1.50 cents on plates.

While much of the buying has been encouraged by the fact that prices were advancing and deliveries were growing harder and harder to secure, it is developed practically beyond question that the consumptive demands of the country have at least grown up to the capacity, if they do not now actually exceed it. It will be recalled that immediately after the financial panic of October, 1907, when the iron and steel trade found itself with output reduced to one-half the former record rate, and with a large amount of new construction in progress, the common statement was that it would require a period of years for demand again to grow up to capacity. It seems to have been somewhat difficult for the trade to realize, in recent months, that the five years intervening since that famous panic have actually elapsed, and to realize also that while at that time there was a large amount of new construction in progress, and carried to completion during the ensuing two or three years, the additions to capacity of late have been relatively small. The actual production of pig iron has increased very little in five years, for the fact is that in October, 1907, pig iron was being made at the rate of 28,000,000 tons a year, whereas to-day it is being made at the rate of 31,000,000 tons. The present capacity is undoubtedly greater than the production, but we have had an average advance of $3.50 in pig iron, from the low point at the beginning of this year, and an average advance of $6 a net ton in pig iron from the low point of last November, and with such encouragement to producers the actual fact is that pig iron is being made at the rate of only 31,000,000 tons a year. The history of the industry has shown a doubling of pig iron production every ten years, on an average, which means two successive increases of 41.6 per cent in five year periods, whereas in the past five years we find an actual increase of less than 10 per cent. Even on the assumption that the production in 1907 represented a rate considerably above normal the present production is not large in the light of past performance, and the pressure upon producers is readily explained.

Pig Iron.

There has been active buying of pig iron in all markets, with almost continuous advances in prices at one point or another. The average advance in the entire market has easily been 75 cents a ton for the month. The blowing in of idle merchant furnaces has been retarded by the great scarcity of coke, which has advanced from $3.75 to $4 at Connellsville ovens for prompt and spot shipment, with contracts for the first half of the new year at about $3. We quote: Bessemer, $17; basic, $16, and No. 2 foundry, $16.50, all f. o. b. valley furnaces, or 90 cents higher delivered Pittsburgh; No. 2X, delivered Phila-

delphia, $18 to $18.50; No. 2 foundry, f. o. b. Chicago furnaces, $17 to $17.50; No. 2 foundry, Birmingham, $14.

Steel.

There is practically no market in billets and sheet bars. The mills are oversold for this year, and are carrying over so much tonnage, besides being under pressure from their own finishing mills, that they are not offering any steel on contract for next year. Occasional small lots are picked up from mills and jobbers, and the market as far as it can be quoted represents an advance of fully $2 a ton in 30 days. On the basis of actual sales, but with no certainty that additional purchases could be made at these figures, we quote: Bessemer billets, $26 to $26.50; Bessemer sheet bars, $26.50 to $7; open-hearth billets, $27 to $27.50; open-hearth sheet bars, $27.50 to $28; rods, $29 to $30, f. o. b. maker's mill, Pittsburgh or Youngstown.

Finished Steel.

During October, wire products advanced $1 a ton, black and galvanized sheets $2 a ton and blue annealed sheets $1 a ton. Plates, shapes and bars advanced $2 a ton. Prices given below represent minimum quotations on contracts, with prompt deliveries in the majority of cases commanding substantial premiums. Prices are f. o. b. Pittsburgh unless otherwise stated.

Rails, standard sections, 1.25 cents for Bessemer, 1.34 cents for open-hearth, f. o. b. mill, except Colorado.

Plates, tank quality, 1.50 cents.

Shapes, 1.50 cents.

Steel bars, 1.40 cents.

Common iron bars, 1.60 to 1.65 cents, Pittsburgh; 1.60 to 1.70 cents, Philadelphia, 1.50 to 1.55 cents, Chicago.

Steel hoops, 1.50 cents.

Sheets, blue annealed, 10 gage, 1.60 to 1.65 cents; black, 28 gage, 2.25 to 2.35 cents; galvanized, 28 gage, 3.40 to 3.50 cents; painted corrugated, 2.35 to 2.45 cents; galvanized corrugated, 3.45 to 3.50 cents.

Tin plates, $3.60 for 100-lb. cokes.

Merchant steel pipe, ¾ to 3-in., card weight, 79 per cent off list.

Steel boiler tubes, 3½ to 4½-in., 72 per cent off list.

Standard railroad spikes, 1.80 cents.

The Non-Ferrous Metal Market.

High prices continue to prevail for the principal non-ferrous metals, and the markets generally are in good condition. Foreign activities are exercising a marked influence on domestic markets. Some spelter has been imported and speculation in tin has been reflected in fluctuating prices.

Copper.—The unsettled conditions abroad have been the cause of a dull market in this metal. The last New York quotations are: Lake, 17⅝@17⅞ cents and electrolytic 17.30@17.40 cents.

Tin.—Statistics published on Oct. 1 tended to lower the price of this metal. The fluctuations in price were caused almost wholly by speculation. A slight premium for spot tin in the domestic market prevailed for a short time, but disappeared later. The latest quotation is 50 cents, New York, for October delivery.

Lead.—Prices remain unchanged at 5.10 cents, New York, and 4.90@4.95 cents, St. Louis.

Spelter.—This market has shown a dullness due to the fact that buyers are quite well supplied. Some metal has been imported. Prices remain high, however, the last quotations being 7.30@7.35 cents, St. Louis, and 7.45@7.50 cents, New York.

Other Metals.—There is a good demand for aluminium at 25@26 cents, New York. Higher prices prevail for antimony on account of the shortage in ore supplies. The last quotatons range from 9 to 10¼ cents for various grades. The quicksilver market is steady at $42 per flask of 75 lb., New York, and $41.50 at San Francisco.

Sterilization of Water by Ozone in St. Petersburg.

The Uprava (Magistrate) and the Duma (City Council) of the City of St. Petersburg in Russia, have agreed unanimously to adopt the ozone method in connection with rapid filtration for the cleaning and sterilization of the water for the city, supplied by the water works at Spalernaja, in view of the good results obtained from ozone water works already in operation at Penkowaja.

Advertisements for proposals for the plant have already been issued, the city having appropriated 10,000,000 rubles for the project. The awarding of contract, based on estimates received, is to take place in the near future.

The original ozone purification plant of the water works of St. Petersburg was described in detail in an article by Dr. G. Erlwein, in our Vol. IX, p. 213 (April, 1911).

CORRESPONDENCE.

Exothermic Steel.

To the Editor of Metallurgical and Chemical Engineering:

Sir: I see in your issue of September 1 an article describing "Exothermic Steel," a new trade product invented by Mr. George Fogler and described by W. O. Amsler, D.Sc.

The fact that the method is patented and that the description is sponsored by a scientific man challenges serious attention to the statements made and forbids us dismissing them as merely fanciful.

The statement is baldly made that a mixture of feldspar, bauxite and lime acts as a reducing agent on iron oxide, reducing it to metallic iron, with a strong exothermic reaction. The aluminium compound in these fluxes is said to act reducingly unon the ore. In practise this reaction is said to be so strongly exothermic as to require some carbon to be admixed in order "to keep the temperature within safe limits."

I am sorry to see any scientific man make such statements. The statements are mere bosh. The chemical equations given as representing the reactions are erroneous, inasmuch as potash feldspar is $KAlSi_3O_8$, and not $KAl_2Si_3O_8$; and while the extra free atom of aluminium is needed to complete the equations given and to supply the exothermic heat talked about, yet unkind Nature has not supplied it in potash feldspar.

The author further talks about running a "matte" furnace with such a charge, with some carbon admixed to keep the temperature down *(sic)*, and blowing in oil or gas flames by air under pressure. The metal does not appear in this "matte" in its free state, but "exists in a state of solution or similar condition, or perhaps even as a silicate of iron, although the writer is inclined to doubt this."

I share his doubts; in fact, I will go him several better, and *doubt the whole thing* until some reputable metallurgist describes the operations in terms which are understandable, and makes statements which are believable. Jos. W. Richards

Lehigh University.

* * *

To the Editor of Metallurgical and Chemical Engineering:

Sir: In the September issue of your journal an article written by Mr. Walter O. Amsler, D. Sc., Pittsburgh, Pa., under the title "Exothermic Steel," in which he sets forth the theory or explanation of an "exothermic reducing reaction between a metallic oxide and a compound silicate of aluminium by which the formation of aluminium oxide takes place." By the use of felspar and bauxite together with limestone to make a fluid slag, he states, the temperature would run too high and therefore enough carbon is charged to reduce a part of the (metallic) oxide by formation of carbon oxides to keep the temperature within safe limits.

The author of this article then proceeds to give us the chemical formula of felspar as ($KAl_3Si_3O_8$). This appears to be an error, but the same formula is used in the two equations which

are intended to represent the reaction supposed to take place.

The chemical formula of felspar as given by authorities on the subject is ($KAlSi_3O_8$) or ($K_2OAl_2O_3 6\,SiO_2$) and by the use of this formula no equations can be written showing the reaction without carbon as given by the author.

In the second equation where the presence of carbon is considered we can only show reduction directly due to the carbon alone.

Exception must be taken to the writing of hydroxide in an equation representing high temperature reaction where it would be impossible for hydroxides to remain as such.

I do not attempt to suggest that steel possessing special qualities could not be made by the process; but I make these remarks in the hope that the author will withdraw this chemical explanation or make it compatible with our present knowledge of chemistry of silicates.

Pittsburgh, Pa. F. GELSTHARP.

* * *

To the Editor of Metallurgical and Chemical Engineering:

SIR: It is particularly gratifying that Dr. J. W. Richards, of Lehigh University should take such vigorous exception to certain statements in the article on "Exothermic Steel" that appeared in your September issue, and that he should italicize his doubts "of the whole thing." The matter must be original to say the least.

It is natural that the pedantic scientific mind should be conservative, if anything, and that it should require anything out of the accepted scheme of things to come from a "reputable metallurgist who makes statements that are believable."

If it is a bald statement to say that feldspar and bauxite with lime react upon an iron oxide in the manner stated in article to reduce the iron with the evolution of heat, it is also a statement of a bald fact. I realize that the exothermic reaction is contrary to the accepted theory of the construction of feldspar and bauxite, but it is really not my fault that these things happen.

The formula for feldspar as given in the article is not as accepted by the authorities, but I can challenge my critic to prove, in a practical way, that somewhere in the reduction by this process, such a reaction as given does not take place. Unless carbon and silicon have different properties when in this flux than generally attributed to them, it would appear to me that the oxidation of aluminium must be assumed to account for the evolution of heat that undoubtedly appears.

The paragraph of the article referring to the rise of temperature being too great unless carbon is used, is capable of misinterpretation. The heat could no doubt be taken care of by using a proper lining, but the temperature would be higher than necessary. Neither is it made clear that the use of too much flux in proportion to the charge of ore will not give good results as it tends to choke the furnace. Yet when using a certain proportion, the resultant metal is so hot that it can be used for welding purposes.

It surely would require a bold theorist to describe the "matte" (this word is used for want of a better one) furnace, its operation and cost sheet together with that of the open-hearth precipitating furnace if such a plant had not been in actual operation.

In conclusion this insurmountable fact obtrudes itself: the process is used to produce a steel that is being sold. If it were all bosh as Dr. Richards is pleased to call it, the steel would not be purchased by our government for use where it gives better service than any other steel. If any critic will submit a better chemical explanation of the matter than the one given it will be thankfully acknowledged. But in the meantime it must be remembered that the process is in actual commercial use, and the exact nature of the chemical reactions taking place must be considered as an academic problem. Constructive criticism will be welcomed.

Pittsburgh, Pa. WALTER O. AMSLER.

Typical Analyses of Iron Blast Furnace Gases.

To the Editor of Metallurgical and Chemical Engineering:

SIR: The accompanying table may be of interest to those engaged in the blast furnace end of pig iron manufacturing. It is compiled from 860 different tests and covers a range of twenty odd furnace linings. It is as near relative as can be put together with ordinary methods of analyses.

A close examination will disclose a few variations from a direct comparison. This is particularly so in the percentage of hydrogen, which varies at different times of the year and depending upon the amount of water used in wetting down the materials before changing and in the varieties of cokes used.

TABLE SHOWING QUALITY OF GASES PRODUCED IN THE BLAST FURNACE, USING NATURAL AIR AND WITH THE CORRESPONDING COKE CONSUMPTIONS.

Pounds of coke per ton of metal.	Product.	Gas Analyses. CO_2.	CO.	H.	N.
3200 to 3400	Spiegel	6.2	30.9	2.3	60.6
3400 to 3500	Spiegel	7.0	30.0	3.5	59.5
4800	Ferro-silicon	3.5	32.5	2.0	62.0
5300 to 5400	Ferro-manganese	4.6	32.6	1.2	61.6
5400 to 5500	Ferro-manganese	3.6	32.2	2.2	62.0
5500 to 5600	Ferro-managese	5.0	28.0	2.6	64.4
5700	Ferro-manganese	3.4	33.8	2.4	60.4
5800	Ferro-manganese	4.3	33.1	1.7	60.7
5900	Ferro-manganese	3.8	32.9	2.4	60.7
6000	Ferro-manganese	5.0	34.4	2.7	57.9
6100	Ferro-manganese	3.0	31.2	2.0	61.8
6500	Ferro-manganese	4.4	30.8	2.2	62.6
7503	Ferro-manganese	3.6	32.4	2.4	61.6
2100 to 2200	Bessemer iron	13.1	24.1	1.7	61.1
2200 to 2300	Bessemer iron	12.1	23.9	2.0	61.9
2300 to 2350	Bessemer iron	11.8	25.6	2.1	60.5
2350 to 2400	Bessemer iron	11.8	24.8	1.9	61.4
2400 to 2450	Bessemer iron	11.7	25.4	1.4	61.5

Braddock, Pa. J. G. W.

The Electric Steel Furnace and the Use of Titanium in Foundry Practice

To the Editor of the Metallurgical and Chemical Engineering:

SIR: In the article by Mr. Paul Girod entitled "The Electric Steel Furnace in Foundry Practice" in your October issue, page 663, this passage occurs: "Recently a very important improvement has been realized by introducing into electric steel practice for castings the use of special titanium alloys such as manufactured by the Société Anonyme Procédés Paul Girod of Ugine, Savoie, France."

Allow me to point out that if this practice is considered abroad as a very recent improvement it is not so in the United States, as such alloys for a number of years have been manufactured under the Rossi patents, some of which were granted ten years ago. Many thousands of tons of steel during the past four years have been treated with this American product. Regarding the use of titanium alloys in connection with steel made in electric furnace; early in 1908 the writer was using such alloys in steel made in electric furnaces of from 2 to 5 tons capacity, recognizing the fact that by such treatment only was it possible to obtain a product uniform and thoroughly deoxidized.

I am glad that Mr. Paul Girod realizes that titanium will improve electric steel. Three years ago in Italy Major Stassano made a similar statement recommending the use of titanium alloys in making electric steel castings. Mr. Girod further remarks, "Even very small additions of these (titanium) alloys render the steel perfectly quiet and insure the castings to become very dense and free from any blowholes. The number of lost heats can be very much diminished." This means that

titanium additions will thoroughly deoxidize the steel, giving a uniform product.

Mr. Girod frankly admits that titanium reduces the number of lost heats; why is this, considering that the function of the electric furnace is to deoxidize the steel? Because deoxidation is only accomplished if carbide of calcium slag be formed. Every one experienced in the use of the electric furnace knows how difficult it sometimes is to form this carbide of calcium slag; and, personally, basing my statement on experience with several hundreds of heats made in electric furnaces, I will say that in most heats this result is not always perfectly obtained. Consequently if the steel is not deoxidized then why use an electric furnace for making steel castings if it still be necessary to finish the deoxidization by using so powerful a reductor as titanium? Is it to get the sulphur and phosphorus as low as 0.015 when specifications called only for under 0.030 or 0.040? Every steel maker knows that when tensile strength, manganese, and carbon are specified, they have only phosphorus at their disposal to raise the tensile strength, the value of phosphorus as a strengthening agent being about 900 lb. per square inch for each 0.01. Such steel can be made more simply and far cheaper in open-hearth furnaces using as deoxdizer an addition of titanium alloy in the ladle.

I will add to Mr. Girod's statement as follows: A great feature of titanium addition is that the titanium by oxidation is transformed into titanic acid which fluxes all the slag held in suspension in the steel after it has been tapped into the ladle and the quantity of slag so held in the steel is very large when the calcium carbide slag has been formed, the latter being very pasty. Allow me to point out, also, that while ferro-alloys of titanium and silicon combined may be a new way of placing titanium on the market, their use will prove a much more complicated operation than separate additions of ferro-titanium and ferro-silicon. Ferro-titanium alone is very useful, but when an equal quantity of silicon is combined with the alloy the silicon is oxidized last if the deoxidation of the bath has not been completed by the titanium, but if it has the silicon will be dissolved in the steel, thus raising the silicon content to a point very often over the limit imposed by the specifications.

In the case of steel made in the electric furnace, it will very often be found that the silicon is too high, a condition brought about by additions of ferro-silicon during the deoxidation period, or more often by the melting of the roof of the furnace, which introduces silica into the slag, this silica being in turn reduced by the calcium carbide present.

Niagara Falls, N. Y. N. Petinot.

Two Aspects of "Conservation" and the Niagara Power Situation.

To the Editor of Metallurgical and Chemical Engineering:

Sir: I am rejoiced to see the strong stand which Metallurgical and Chemical Engineering in the issue of September 12th has taken editorially against the restriction of power development of Niagara Falls. From an industrial viewpoint every cubic foot of water that goes thundering over the great cataract unutilized is sheer continuing waste of national resources.

"Conservation" which conserves only gigantic waste strikes the ordinary citizen as being very far from an ideal display of governmental activity. The distribution of power from Niagara, now extending over a radius of many miles, has been of general benefit and the cessation of this development is a thing to be lamented not only as a purely industrial matter, but out of regard for the welfare of the whole people.

I am by no means deaf to the æsthetic and sentimental arguments for the restriction of power development at Niagara, indeed I would willingly agree that the country might be better off for "letting in the jungle" upon certain spots now obnoxiously populous. But granting the general weight of the sentimental argument, I have not been able to see how it applies to Niagara, which was already robbed by its sordid environment of most of its æsthetic value long before electrical developments there began.

Could the scene be preserved in its pristine magnificence, surrounded by virgin forest, and silent save for the deep-voiced roar of the rainbow-crowned cataract, it might have been worth the while. For a good many years, however, the surroundings have gradually grown more and more tawdry and sordid. The forests have long since been swept away. The landscape has been defiled with shabby hotels and cheap factories and the voice of the waters has been drowned by screeching steam whistles, the clatter of the street, and the raucous voices of hackmen and guides. The fact is, that Niagara as a majestic spectacle has never belonged to the present generation. It was given up to noisy and offensive exploitation long before the first dynamo was set spinning at its brink.

"Saving Niagara," from the æsthetic standpoint, is a sorry joke, like saving forests by selling the charred slashings to the Government after every stick worth cutting has been carried away. But the cataract, no longer able to teach its primal majestic lesson, can at least teach humanity something of the beauty of labor. If I read its mission aright it is to scatter productive industry over the face of the country for a radius of 500 miles or more, to bring the means of efficient industrial development within the reach of hundreds of communities. Such a distribution of power will not only build up material things, but it will help serve the things of the spirit by opening wide the gates of industry instead of closing them prison-wise on a few overgrown and unlovely manufacturing cities.

As a citizen, hopeful of my country's future, I do not like the Great Industrial Center. From even the material standpoint it is too often merely a center of squalor, poverty, and wretchedness, where all the evil forces that arise from these are felt with their fullest power. We, in Massachusetts, have had ample opportunity to observe the effect of great aggregations of underpaid, underfed, low-grade labor seething with unrest and only temporarily quieted by the clubs of the police and the bayonets of the militia. Our great industrial centers have become powder magazines, of their own loading, upon which too many of the self-styled "better class" sit and complacently smoke. And I have long believed that the best remedy for these conditions is to be found in further reaching opportunities for industry, in the equalization of working facilities over broad stretches of country, and that the widespread distribution of transmitted electrical power is one of the most efficient means for promoting this end. It has been successful in saving scattered industries abroad. It is showing signs of success in building up such industries here.

When the power of Niagara is diffused over the states of New York and Pennsylvania and the Province of Ontario, communities now moribund will spring into active life again, and we shall see the prosperous and active manufacturing town of a generation ago here, there, and everywhere, supplanting the great industrial center that is coming to be from the viewpoint of the sociologist a sort of outwork of Tophet. If the governments of the United States and of the Dominion of Canada could get together and encourage the development of Niagara, and the boards of trade in all the towns within its radius of distribution could get busy and take advantage of the opportunity, the cataract would be doing work of which both nations could be justly proud, instead of failing as a spectacle and shirking its most obvious utility.

If there are those who from motives of curiosity would wish to see what Niagara was like when it was going to waste, it would not be difficult to arrange on, say, the Fourth of July and Dominion Day, joint local holidays, of which we have none too many, on which the great stream could be turned in the main into its former channels for the sake of "Auld Lang Syne."

At present it is neither adequately ornamental nor properly useful.

Boston, Mass. Louis Bell.

The Death of Dr. Morris Loeb.

Dr. Morris Loeb, president of the Chemists' Club, of New York, and former professor of chemistry in New York University, died at Seabright, N. J., Oct. 8, 1912, from typhoid fever and double pneumonia after a brief illness, not yet fifty years old.

At a meeting of the trustees of the Chemists' Club, held on the evening of Oct. 8, the following preamble and resolution was ordered to be filed:

"Whereas, Morris Loeb, the president of the club, has been taken from us by death, and

"Whereas he was the leading spirit in bringing to fulfillment ambitions and plans that had long been ours, and

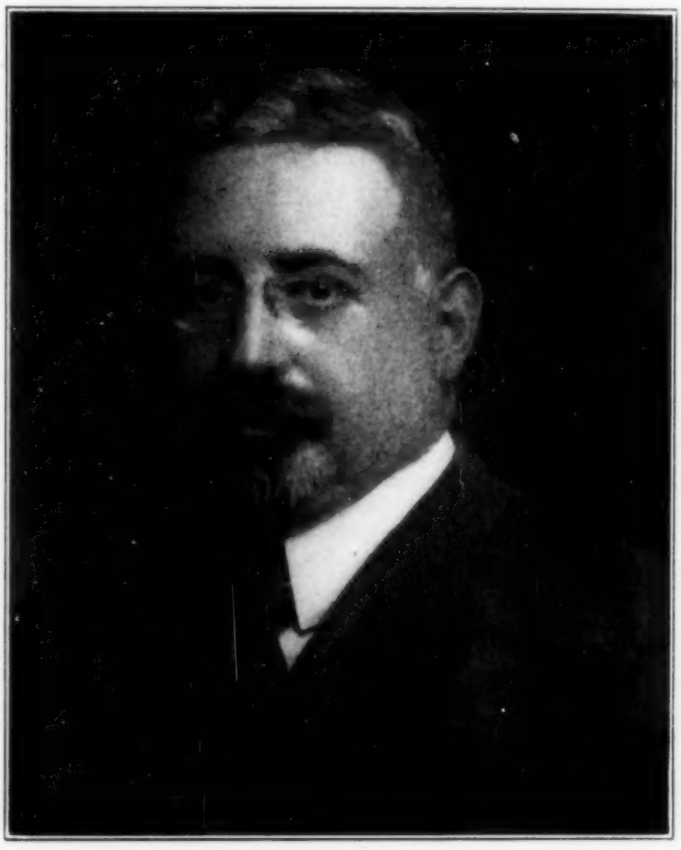
"Whereas he was always ready to shoulder burdens and to give help, and

"Whereas he was a man of order, and of integrity in mind and heart, sincere in scholarship, living without malice or scorn, speaking no evil, and generous in judgment, and

"Whereas we were drawn to him by ties of deep and abiding affection, now, therefore, be it

"Resolved, that we make this minute of our poignant grief at his passing, and that we cherish his memory as another of his great gifts to science and to humanity."

* * *



THE LATE MORRIS LOEB.

Morris Loeb was born in Cincinnati on May 23, 1863, a son of Solomon and Betty Galenberg Loeb. His father was one of the founders of the banking firm of Kuhn, Loeb & Company. He was educated at the Dr. Julius Sachs School and later in Harvard University, where he received the degree of Bachelor of Arts in 1883. In 1887 he graduated from the University of Berlin with the degree of Doctor of Philosophy and for a year thereafter he studied at the Universities of Heidelberg and Leipzig.

From 1888 to 1889 he was assistant to Prof. Wolcott Gibbs at Harvard University and from 1889 to 1891 docent of chemistry at Clark University. Thereafter, for sixteen years, from 1891 to 1906, he was professor of chemistry and director of the chemical department of New York University. This position he resigned in 1906 in order to take up private chemical research of his own and to devote himself more largely to philanthropic and commercial work.

In 1895 Professor Loeb married Miss Eda Kuhn, of Cincinnati, of the Kuhn family which represented the second branch of the founders of the banking firm of Kuhn, Loeb & Company. Mrs. Loeb survives him.

Distinguished as Professor Loeb was for his original work in chemical research, of even greater influence was his indefatigable work for the Chemists' Club in New York and thus indirectly for American chemistry. "He was a charter member at the organization of the Chemists' Club in 1898. Twice he was vice-president and twice president. It was during his first presidency in 1909 that the idea of having a clubhouse of our own, an idea which had been vaguely in our minds before, now took definite shape. His wise counsel, his time and his generosity were unselfishly placed at the disposal of the Chemists' Club, and it is not too much to say that to him more than to any other one man the chemists of America are indebted for a chemists' club and clubhouse absolutely unique in the world. When we occupied the new club quarters, this same wise counsel and generosity were invaluable. The entire furnishings of Rumford Hall, of the Priestley Room, of the library and museum were at his expense. Scarcely a room in the club is without some mark of his thoughtfulness and generosity. Though his path through life was smoothed more than happens to most of us, his days were filled with activity, and he was a living embodiment of how fivefold it increases the value of a benefaction when the giver's time and counsel and interest go with it. His many memorials in the clubhouse will not be needed to make us remember him."

In 1911 Professor Loeb and his brother contributed $50,000 for the Wolcott Gibbs Library at Harvard University, where he had previously founded the Association of Harvard Chemists.

Professor Loeb was a generous patron of music and art, a philanthropist and public citizen. At the time of his death he was a member of the Board of Education of New York City. His charities were many and by no means limited to his own race. He was president of the United Jewish Charities Building, a member of the American Jewish Committee, a trustee of the Jewish Theological Seminary of America, and formerly president of the Jewish Agricultural and Industrial Aid Society. He was founder of the Betty Loeb Musical Foundation and a director of the Educational Alliance.

The following is a list of the papers which Professor Loeb published in the twenty-seven years during which he worked as an original investigator in chemistry:

Action of Carbonyl Chloride on Ethenyldiphenyldiamine (Diphenylacediamine), *Ber., 18*, 1885, p. 2427-8.

Amidine Derivatives, *Ber., 19*, 1886, p. 2340-4.

Phosgene and Its Derivatives with Contributions on Their Characteristics, Thesis, University of Berlin, March, 1887; also *Chem. Centralbl., 18/1*, 1887, p. 635-7.

Molecular Weight of Iodin in Its Solutions, *J. Chem. Soc., 53*, 1888, p. 605-12.

Use of Aniline as an Absorbent of Cyanogen in Gas Analysis, *J. Chem. Soc., 53*, 1888, p. 612-14.

Molecular Condition of Dissolved Iodin, *Z. Physik. Chem., 2*, 1888, p. 606-12.

Kinetics of Substances in Solution (with W. Nernst), *Z. Physikal. Chem., 2*, 1888, p. 948-63.

The Use of the Gooch Crucible as a Silver Voltameter, *J. Am. Chem. Soc., 12,* 1890, p. 300-1.

Osmotic Pressure and the Determination of Molecular Weights, *Am. Chem. J., 12,* 1890, p. 130-5.

The Electrolytic Dissociation Hypothesis of Svante Arrhenius, *Am. Chem. J., 12,* 1890, p. 506-16.

Is Chemical Action Affected by Magnetism? *Am. Chem. J., 13,* 1891, p. 145-53.

Apparatus for the Delineation of Curved Surfaces in Illustration of Gases, etc., *J. Am. Chem. Soc., 13,* 1891, p. 263-4; also *Chem. News, 65,* 1892, p. 220-1.

Crystallization of Sodium Iodide from Alcohols, *J. Am. Chem. Soc., 27,* 1905, p. 1019-20.

Hypothesis of Radiant Matter, *Pop. Sci. Monthly, 73,* 1908, p. 52-60.

Conditions Affecting Chemistry in New York, *Science, 30,* 1909, p. 664-8.

Analysis of Some Bolivian Bronzes (with S. R. Morey), *J. Am. Chem. Soc., 32,* 1910, p. 652-3.

Oliver Wolcott Gibbs, *Proc. Am. Chem. Soc.,* 1910, p. 69-75.

Abstractor (Italian) for Chemical Abstracts, 1908, 1909, 1910.

Address at Opening of Chemists' Building, *Met. & Chem. Eng'ing,* 9, 1911, p. 177-8.

A New French Chlorate and Perchlorate Plant.

Near the little village of Epierre, between Chambéry and Modam in the French mountains, a new electrolytic chlorate factory has been erected in 1911. This new plant is situated in the industrial valley at Maurieune, where the power from the Arc River is already being utilized for numerous large electrochemical plants. Industrially it is one of the most interesting valleys of Savoy. The proprietors of the plant are Messrs. Davey-Bickford-Smith & Co. of Rouen, who are well known all over the world for their explosives. The factory is called the Usine de la Corbière in St. Pierre de Belleville (1 kilometer from Epierre).

The electrical power is produced from the water of a little river coming down at St. Pierre de Belleville from a height of 1100 meters over sea, while the power house is at the level of 369 meters so that a fall of 731 meters is utilized. The power produced is in the average 1500 h.p. (varying from 800 to 3000 h.p.). The water used by one turbine (500 h.p.) at full load is 70 liters per second.

The upper part of the pipe line is a pipe of 2500 meters

POWER HOUSE AND CHLORATE PLANT.

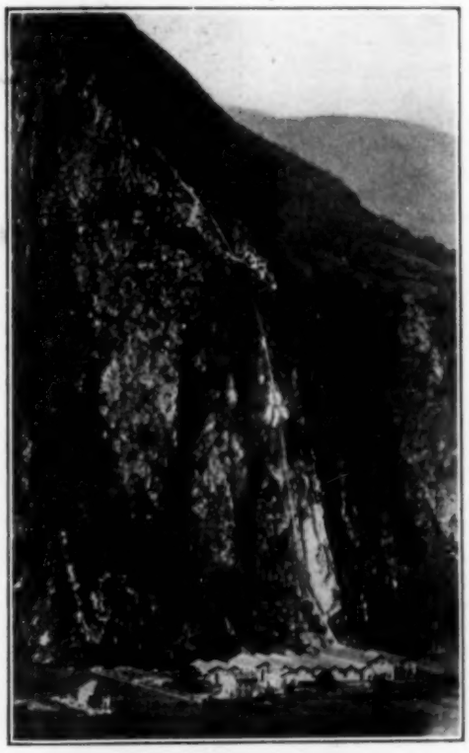
length of reinforced concrete. The first upper part of the steel tube line has an inclination of about 55 degrees, the lower part, a welded steel tube, 75 to 80 degrees inclination. The total length of this iron-steel tube is about 1500 meters. The difficulty of fitting up this last part of the tube was very great. It was done by the well-known firm of Joya et Cie in Grenoble, who are specialists in this matter.

The power house has room for six high-pressure turbines or Pelton wheels. Five have been installed and are coupled to the driving shaft of the dynamo, which generates 1500 amperes at 220 volts, the speed being 450 r.p.m. The turbines and dynamo are provided with good regulators and all apparatus generally used in order to avoid any kind of accidents. The continuous current produced is carried to the electrolytic plant.

The turbines were furnished by J. J. Rieter in Winterthur, Switzerland, and the dynamo by Schneider & Co., Champagne sur Seine, near Paris.

Electrolytic Plant.

Three hundred cells producing about 5 tons per day of chlorate of potash are installed. The electrolytic cells and the process were invented by M. Couleru, of Paris, expert in chlorate and perchlorate manufacture. The anodes used are very thin sheets of platinum, the cathodes and the cells are of cast iron. For insulation mica is used. The apparatus is working continuously and so is the feeding of fresh liquors.



USINE DE LA CORBIÈRE.

The solution leaving the cells is conducted to the cooling tanks.

Instead of platinum graphite is also used and this use is very interesting at the present time since platinum is very dear.

Large concrete or iron tanks are used for the cooling of the solutions. Artificial cooling in the electrolytic cells or in these tanks may be employed successfully in order to save time and to reduce the cost of the first installation. The warm water obtained by cooling can be used for several purposes.

The raw chlorate is dissolved in hot water for refining. The apparatus used is the same as generally employed, namely, iron tanks, brick pans, drying installations, grinding mills, etc.

During the dry summer of 1911 the water was very scarce and in order to increase the power two other waterfalls were purchased at Epierre and the total power is now in the average of 3500 h.p. The excess power will be used for other products.

The chlorate plant at Epierre has been recently purchased by the International Chlorate Syndicate. The work at Epierre is continued by the Société Universelle d'Explosifs of Paris, and the manufacture of perchlorates, especially of ammonium perchlorate, will be taken up. Chlorate of sodium will also be produced on a large scale. Both products will be used for explosives only.

Iron Ore Concentration in Minnesota.

Editorial Correspondence.

The production of merchantable iron ore, by means of wet concentration, from material which is too low-grade for profitable reduction in the blast furnace, is one phase of the great iron and steel industry which is in its infancy. That it has been successfully done on a large scale, leads to the belief that it is an important step toward the genuine conservation of our iron resources, and one that will be followed by others which, in time, will make available much ore now without commercial value. This means not only the utilization of low-grade deposits, but the conservation of the best ore for special purposes, or for raising the average grade and quality of a large tonnage of less desirable ore.

Special systems of concentration have had to be devised to meet the requirements of iron-ore production. The intrinsic value of a ton of iron ore is not great enough to warrant too elaborate a system of treatment, while smelting conditions demand an ore with as much lump and as little fine as possible. Tonnage and physical condition of the product, therefore, become important factors in this business. The former is equally important in the treatment of other low-grade ores, such as gold or copper. In these cases, however, it becomes necessary to resort to elaborate systems of grinding and fine concentration, which, fortunately, can be dispensed with in the concentration of iron ore.

In point of tonnage capacity of a single plant, there are no other ore-dressing mills in the United States which approach the magnitude of the largest iron concentrator. The great copper concentrating mills of Utah and Arizona, having individual capacities ranging from 3000 to 12,000 tons in 24 hours, are still small compared with the Trout Lake mill of the Oliver Iron Mining Company, with its capacity of 35,000 tons in 20 hours. And yet, owing to the more complex flow-sheet of the former, and consequently the larger number of machines used and greater acreage covered, they make an impression more nearly in keeping with their magnitude than does the iron concentrator.

Trout Lake Mill, Oliver Iron Mining Company

The first and larger of the two iron concentrating mills in Minnesota, was built by the Oliver Iron Mining Company, on Trout Lake, near the western end of the Missabe range, where the ore is lower-grade than it is farther East. Here, also, the company has built the model town of Coleraine, beautifully situated on the north shore of the lake, and made attractive by substantial buildings, good schools, broad streets, cement curbing and sidewalks, and a system of artistic street lighting.

An exterior view of the mill is given in Fig. 1 and a flow sheet in plan and elevation in Fig. 2. The railway approach to the mill is over a long fill of earth and rock removed in stripping the iron deposits. This approach ends in a steel trestle, shown in the figure, reaching a height of 110 ft. above the ground, and giving the necessary elevation for a gravity flow of ore through the mill.

Unit Construction.

The flow-sheet, Fig. 2, represents one of the five units, each under independent control. The capacity of each unit is 350 tons per hour, and as the mill is operated during two shifts of 10 hours each, or 20 hours per day, the capacity of the whole mill is 35,000 tons per day. The crude-ore bin for each unit will hold 500 tons of ore, or about 1½ hour-supply for the unit. The views shown in Figs. 4 and 5, although taken in another plant, represent similar construction in a unit of the Trout Lake mill.

As shown in the flow-sheet, the concentrating machines of a unit are one conical screen (2-in. openings), two 25-ft. log-washers, two 18-ft. turbo-washers, and twenty Overstrom con-

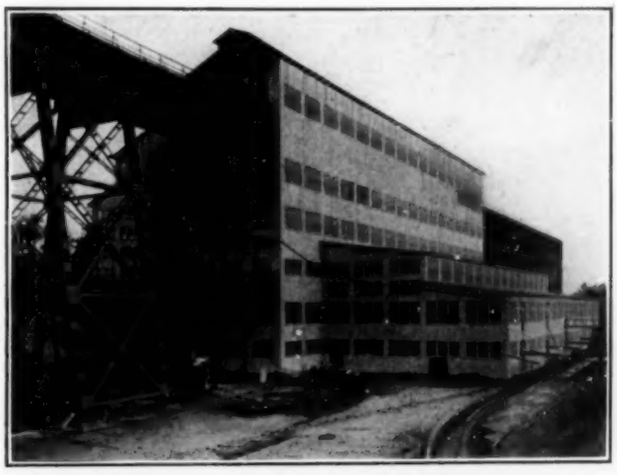


FIG. 1.—IRON-ORE CONCENTRATOR, OLIVER IRON MINING COMPANY.

centrating tables, with the necessary complement of settling tanks, pumps and bins. The ore is sluiced from the bin onto a grizzly (6-in. openings), where large pieces of waste rock are

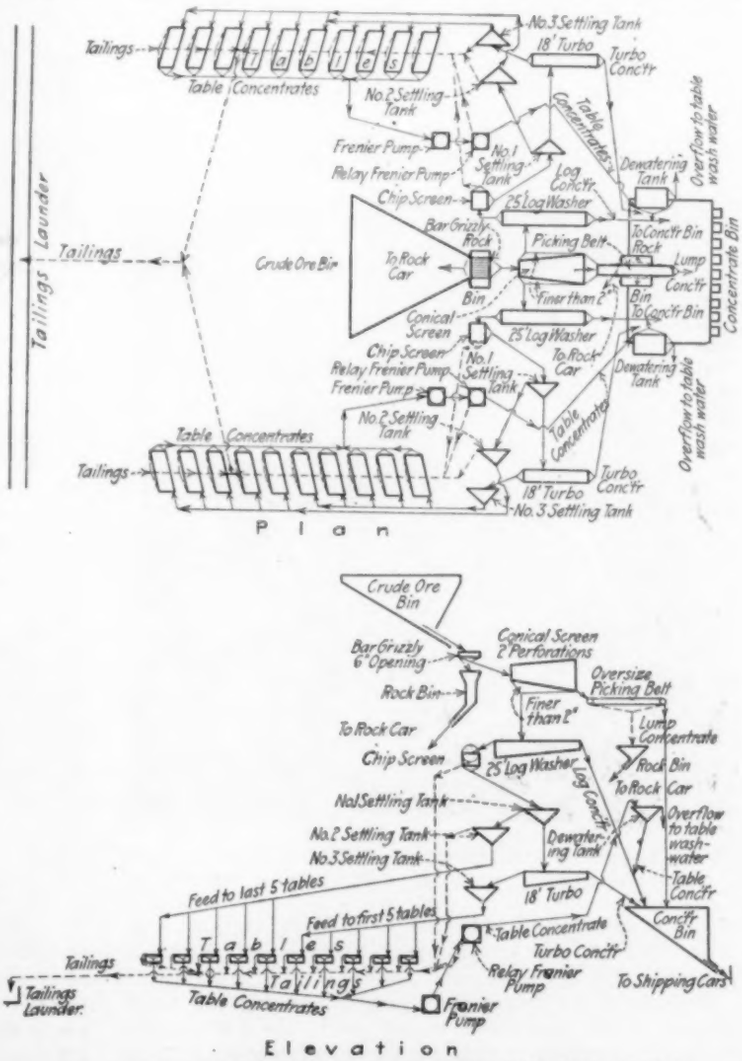


FIG. 2.—FLOW SHEET, TROUT LAKE CONCENTRATING MILL, OLIVER IRON MINING COMPANY, COLERAINE, MINN.

sorted out, and large pieces of ore broken to pass on to the conical screen. The oversize of the latter passes onto a picking-belt (Fig. 5), the rock being picked out and discarded, while the lump concentrate passes on to the bin.

The 2-in. undersize of the screen flows to the log-washers on either side (Fig. 4). These machines produce a coarse concentrate which passes to the bin, the overflow being thickened and

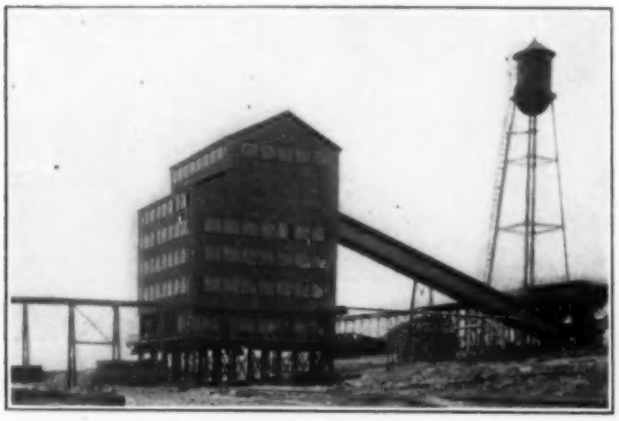


FIG. 3.—IRON ORE CONCENTRATOR OF WISCONSIN STEEL COMPANY, NASHWAUK, WIS.

treated in the turbo-washers, which are practically smaller log-washers in which the feed is kept well agitated by numerous jets of water rising from the bottom of the casing. Between the logs and turbos are so-called "chip" screens or trommels, to separate and remove "chips" of rock which are carried in the overflow of the log-washers. The turbo-washers produce a smaller size concentrate, and their overflow is thickened, and

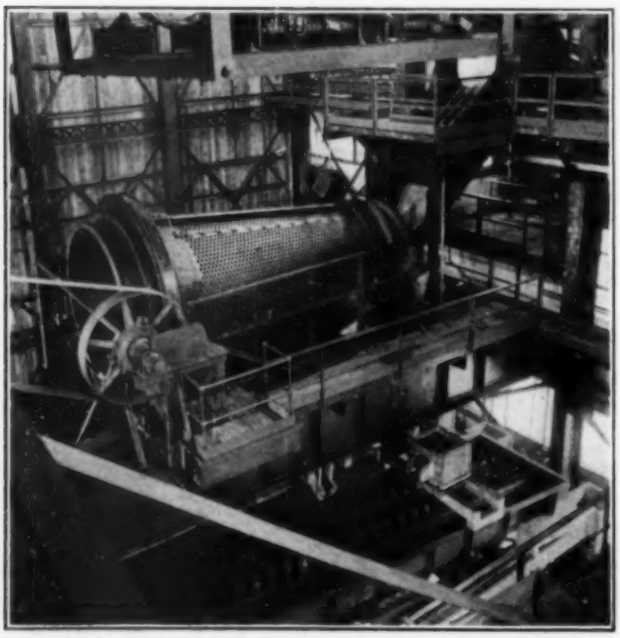


FIG. 4.—INTERIOR OF CONCENTRATOR OF WISCONSIN STEEL COMPANY, NASHWAUK, MINN., SHOWING SCREEN AND LOG WASHER.

treated on tables. The table feed is clearly shown in the flow-sheet. The table concentrate is elevated by Frenier pumps, in two stages, dewatered and sent to the bin.

A 100-hp motor drives the conical screen, log and turbo-washers, and a 15-hp motor serves the twenty concentrating tables. The perforated plates of the conical screen are ¾ in. high-carbon steel, and last about 100 days. The chilled-iron paddles on the logs last from five to six months. The decks of the Overstrom tables have been remodeled to suit the conditions, by removing the riffles and substituting a corrugated wood surface. This change resulted in increasing the efficiency of this department nearly 50 per cent.

The grade of the crude ore as it comes from the pits ranges from 35 to 42 per cent iron. The concentrate averages 57 per cent iron, and represents about 67 per cent by weight of the crude ore treated. The phosphorus content of the concentrate is slightly greater than that of the crude ore. All tailings are combined and sent to the Lake through a concrete flume, seen at the right in Fig. 1.

The pump and power station is situated on the shore of the lake, about 1¼ miles below the mill. The power plant, consisting of boilers, engine and 1250-kw generator, is capable of supplying twice the amount of power required in the mill, but the capacity of the pump is not much greater than the steady mill demand of 8000 gal. per minute. Water is raised a total height of 255 ft. above the lake, being delivered through a 30-

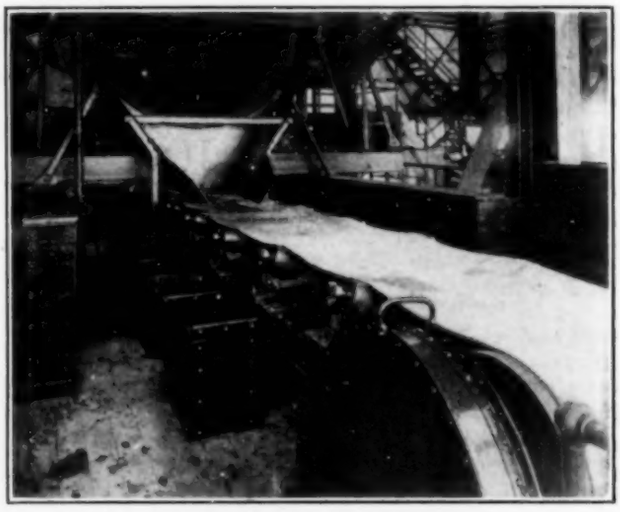


FIG. 5.—PICKING BELT BELOW SCREEN, NASHWAUK PLANT, WISCONSIN STEEL COMPANY.

in. pipe-line to a 110,000-gal. tank erected on a steel structure near the mill. The tank is in no sense a storage reservoir as it holds only about 15-minutes supply, but simply provides the necessary head of water for the mill.

Wisconsin Steel Company's Mill at Nashwauk.

The second iron-ore concentrator built in Minnesota was erected by the Wisconsin Steel Company, to treat ore from the Hawkins mine at Nashwauk. With the exception of some changes, which will be noted, it was modeled after the Trout Lake mill, in which a test run of 1000 tons of Hawkins ore was made, to see what results could be obtained. The two main points of difference are in the method of delivering the crude ore to the head of the mill, and in the extent to which fine concentration is carried. In the Nashwauk mill, Fig. 3, the ore is elevated from the railroad ore-pockets by means of a belt conveyor, passing then through a concentrating system similar to that at Trout Lake, except that no concentrating tables are used.

By reference to Fig. 3, it will be seen that ore is delivered by railroad to two ore-pockets of 250-tons capacity. Below the pockets are shaking launders arranged to deliver to a common point. In operation they discharge alternately onto a 3-ft. rubber-belt conveyor set at an inclination of 19 deg. The conveyor is about 150 ft. long and discharges ore onto a 6-in. grizzly at the head of the mill at a point corresponding to the mouth of the crude-ore bin in the Trout Lake mill. The head pulley of the conveyor is discernible in the upper part of Fig. 3.

The operation of the shaking launders is controlled by one man at the ore-pockets, and the movement of the belt conveyor is governed by the men at its upper end, whose duty it is to sort out waste rock and break large lumps of ore which will not pass the grizzly. Should it become necessary to stop the belt, the man at the feeders is signalled by an electric bell, and the feed is temporarily stopped.

The advantages claimed for this system are: First, that it avoids the construction of the long approach required to deliver carloads of ore to the head of the mill; and second, that a more regular feed is insured by eliminating the possibility of sudden rushes of great masses of ore, which sometimes occur in a large bin. Irregularity of feed, of course, subsequently affects the efficiency of the screen and the log-washers, as well as the quantity and grade of concentrate produced.

The decision to omit the concentrating tables in the Nashwauk mill was determined by the fact that only 3 per cent additional recovery could be made by their use; and the ore thus recovered, being fine, would be the least desirable of all the concentrates. When dry it would practically be dust, subject to loss in transportation as well as in the blast furnace, and altogether hardly worth the outlay of capital and operating expense for fifteen or twenty tables.

With the exceptions noted, the concentrating system at Nashwauk is practically the same as at Trout Lake. A minor difference is the use of small grizzlies instead of chip-screens to remove large particles of lean ore and rock from the overflow of the log-washers to the turbo-washers. The punched plates in the conical screen show about the same life as at Trout Lake. When the blades of the log-washers are worn thin, they are not removed, but are patched with pieces of white-iron bolted to the worn blades. The white-iron blades last from five to six weeks.

All concentrates are delivered to the same bin, and in order to mix the coarse and fine, a part of the stream of log-concentrate is diverted to the launder carrying turbo-concentrate befor the latter enters the bin. The ailing flows out of the mill through an elevated launder which discharges onto an area of low land where the solid tailing accumulates, and the water drains back into the small lake near which the mill is built.

Concentration Results.

The ore treated at Nashwauk is higher grade than at Trout Lake, and the product is proportionately of better quality. The crude will average 40 to 45 per cent iron and 15 to 16 per cent silica. The mixed concentrate averages 60 to 62 per cent iron and 3 to 6 per cent silica. Phosphorus is about two points higher in the concentrate than in the crude ore. It has been found profitable for the purposes of this company to concentrate crude ore containing up to 56 per cent iron. Eighty per cent of the iron in the crude ore is recovered, and the concentrate represents about 62 per cent by weight of the crude ore. Of the total product, 10 per cent is lump concentrate from the conical screens and picking belt, 80 per cent coarse concentrate from the log-washers and 10 per cent fine concentrate from the turbos. Sampling is done twice daily, all the concentrates being temporarily diverted to a steel bin provided for this purpose.

Steam-electric power is generated by a Parsons turbine and 500-kw generator, which gives power greatly in excess of the 125 kw required in the mill. The main unit is operated by a 100-hp motor, as at Trout Lake. The belt conveyor consumes about 30 hp and the shaking feeders about 10 hp. A Prescott steam pump of 2500 gal. per min. capacity supplies water to the mill, the consumption being only 1200 gal. per min. This is proportionately less than is used at Trout Lake, due largely to the omission of the tables.

Iron-Ore Concentration a Recent Development.

The mills described are in operation only six months in the year, corresponding to the regular shipping season on the lakes. The Trout Lake mill has finished its third season, and the Nashwauk mill its first. It is interesting to note that both mills far exceeded their rated capacities, practically by 100 per cent, and have given fully as good results as were anticipated. The Nashwauk mill was planned as a two-unit plnt, but the single unit has proved ample for present needs, and the second may not be installed. As much as 8000 tons of ore has been treated in this unit in one day of 20 hours.

At Coleraine, Mr. M. H. Godfrey is general superintendent for the Oliver Iron Mining Company. Mr. Wm. Nicholls, who is superintendent of the Trout Lake mill, was formerly engaged at some of the large Western copper concentrators. Mr. C. J. Mott is assistant superintendent. The Nashwauk mill is under the management of Capt. Sellwood, of Duluth. Mr. B. W. Batchelder, of Nashwauk, is superintendent.

Problems in the Manufacture of Chemically Pure Acids.*

BY J. T. BAKER.

The manufacture of chemically pure acids, hydrochloric, nitric, and sulphuric, is a subject concerning which very little if any literature is to be found. The reason for this is mainly that the manufacture of acids which will pass to-day as chemically pure is limited to comparatively recent years and the methods of manufacture have not yet found their way into chemical publications and textbooks.

Twenty-five or thirty years ago the yearly production of chemically pure acids probably did not exceed one month's production at the present time, and owing to the enlarged field

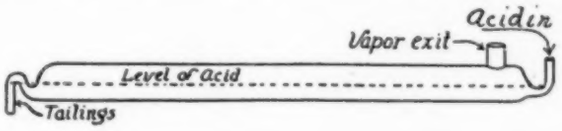


FIG. 1.—IDEAL STILL.

of analytical chemistry, the demand is constantly increasing. The manufacture has now reached a volume which entitles it to be classed as one of the large industries of the country and there are several manufacturing plants devoted in part, if not altogether, to this particular branch of chemical industry.

As a result of the growth of the business, manufacturers have been stimulated, if not obliged by reasons of competition, to devise improved methods of manufacture, in consequence of which the cost of production has been materially reduced and the market prices have fallen during the period mentioned from 50 to 85 per cent. In this connection it is interesting to note some of the improvements which have been made, and

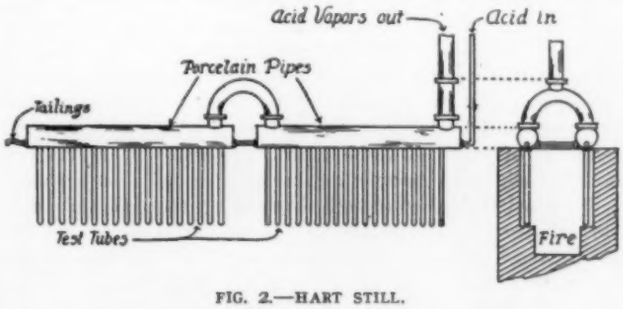


FIG. 2.—HART STILL.

the ingenuity which has been displayed in overcoming some of the almost insurmountable difficulties.

The improvements referred to and to be herein described relate only to the methods of purifying so-called commercial-

* A paper presented before The American Institute of Chemical Engineers. Slightly abstracted from vol. IV of The Transactions of the Institute.

grade or crude acids and not to the actual manufacture of the acid itself, the latter being made by the usual methods more or less familiar to every student of industrial chemistry.

There is doubtless plenty of literature on the chemistry of making pure acids, but the chemistry is generally the simplest part of the problems of industrial chemistry, particularly when working on a large scale, for the greatest problems encountered are generally the mechanical details and cost of production.

It is only within the last score of years that the industry has advanced beyond the laboratory scale both in its methods as well as in the volume of its output. For many years the distillation of the crude acid was performed in glass retorts or flasks of 2 or 3 gal. capacity connected with small Liebig condensers in practically the same manner that distillations are performed in a college laboratory, only on a larger scale, and the amount of labor involved, together with the loss from

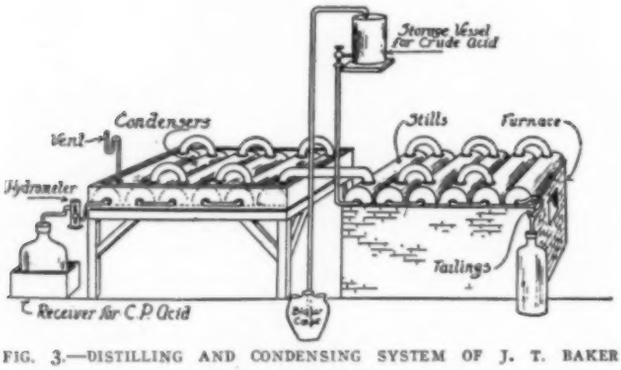


FIG. 3.—DISTILLING AND CONDENSING SYSTEM OF J. T. BAKER CHEMICAL COMPANY.

breakage, made the cost of production not only high but uncertain. It was an interesting sight to see a battery of, say, twenty or thirty retorts side by side on a long sand-bath, each one having a separate condenser with numerous water pipes and stop cocks, all boiling at once; but when one retort accidentally cracked, followed probably by half of the whole battery and the contents suddenly disappeared in a dense cloud through the ventilators of the roof, the sight was rather disheartening.

The great problem was to device a still of small capacity, but with a large heating surface which could be operated continuously by supply crude acid as rapidly as the distillation proceeded, so that the quantity of acid in the still at any one time should never be very great and consequently little lost in case of breakage. Another advantage to be gained by such an arrangement would be the saving in time in getting the distillation started, as there would be but a small volume of liquid to be heated, while in a large still much time is lost in bringing the contents up to the boiling point, not to mention the loss of heat by radiation from the sides of a large vessel.

One great difficulty, however, connected with such still is the necessity of removing the impurities remaining in the tailings, which if allowed to become concentrated beyond a certain point will cause trouble by crystallizing out or spurting and being carried over into the distallate, while if an arrangement is made to draw off the tailings either continuously or intermittently, when using a still of the ordinary compact form, such as a retort or flask, much good acid is liable to be wasted.

An ideal still that will solve the problem is illustrated in Fig. 1, and consists of a long glass tube with an opening at one end to admit fresh acid and one at the other end to draw off the tailings, the openings being in the form of traps to prevent the escape of the vapors, for which an exit is provided near the end at which the acid is admitted.

The still is kept about half-full and is heated from underneath along the entire length, the greatest heat being at the end near the exit of the tailings. The still being long and narrow there will be a constant movement of the contents toward the outlet, at which point the impurities will collect and will gradually be drawn off with the tailings at a rate that will avoid any trouble from crystallizing or spurting. Even if spurting should occur at this point it is so far from the exit for the vapors that there is no danger of any of the impurities being carried over into the distillate. With a constant supply of fresh acid entering the still to replace the contents as rapidly as it distills off, the distillation may be kept up indefinitely.

Such a still as the above, while perhaps practicable as a laboratory experiment, would not answer for operating on a large scale, because owing to the fragile nature of the material available for the purpose, it is not possible to construct such an apparatus that will be durable. The same principle involved has, however, been worked out successfully in various other ways and some of the apparatuses designed are protected by patents.

One of the original inventions was known as the Hart system and one which has proved to be as efficient as it was ingenious, is constructed of glass test tubes. The apparatus is illustrated in Fig. 2. A porcelain vessel in the form of a pipe, say, 4 ft. long, 6 in. diameter, is made with a row of openings close together along one side, into which glass tubes closed at one end and similar to a test tube, say, 18 in. long by 1½ in. diameter, are inserted and the joints made tight with rubber gaskets or asbestos fiber. The vessel is provided with a

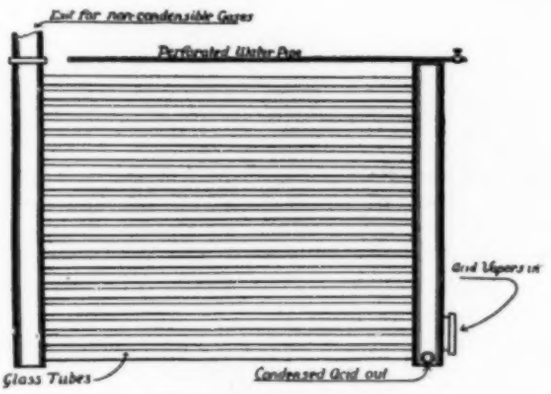


FIG. 4.—HART CONDENSER.

small opening at each end, one for the supply of fresh acid and the other for drawing off the tailings, and a larger opening on top to carry off the vapors. The vessel is supported on the brickwork of the furnace with the glass tubes depending downward and exposed to the direct heat of the fire.

A number of such apparatuses may be connected together and are placed on a level so that when the acid is admitted it will by seeking its level be at the same depth in each vessel and on a level with the outlet for the overflow of the tailings. The boiling takes place in the glass tubes, which afford large heating surface, and the distillation is exceedingly rapid, but may be easily controlled by regulating the temperature of the fire. The durability of the tubes depends upon the quality of the glass, but, as a rule, they stand the strain well and with proper care on the part of the operator the apparatus works quite satisfactorily. If occasionally a tube breaks, it can be replaced with comparatively little trouble without taking the apparatus apart, and the quantity of acid lost is trifling because there is so little in the apparatus that can run out.

When working steadily the still is very efficient, a battery of four having a capacity of about 2000 to 3000 lb. of distillate per twenty-four hours, and if facilities are provided for supplying the acid to the stills by gravity so as to avoid unnecessary handling, the labor involved will be a comparatively small

item of expense, while the loss in breakage and the cost of fuel is reduced to a minimum. This invention has been patented.

Another system of still constructed on the same principle of continuous operation and one which has been used for a number of years by the J. T. Baker Chemical Company is made entirely of porcelain, and having less joints there is less liability

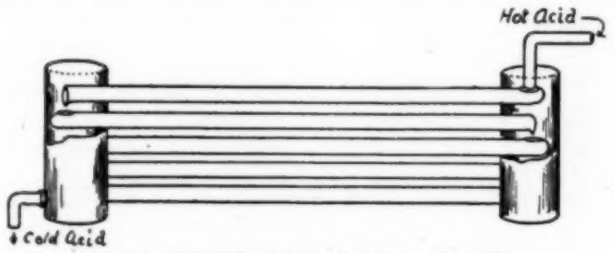


FIG. 5.—BLEACHING AND COOLING APPARATUS.

of leakage than in the apparatus above described, particularly where the joints must be made with asbestos, as in the case of nitric acid.

Under certain conditions porcelain will withstand the strain of great heat better than glass, and it has been found feasible to distill acid from porcelain vessels of considerable size without danger of breakage. An apparatus of this construction is illustrated in Fig. 3 (which, by the way, also illustrates a condensing system to be referred to later).

The vessels measure about 3 ft. in length by 8 in. in width and are flat on the bottom in order to obtain a large heating surface. A number of vessels, say 10, are laid side by side on top of the furnace directly over the firebox and are connected together with small glass tubes near the bottom to conduct the acid through each vessel in succession and with porcelain goose-neck pipes for the passage of the vapors. The large extent of heating surface which the vessels afford makes the apparatus a very efficient still without forcing the fire and running the risk of cracking the porcelain, which owing to the size and nature of the ware has comparatively thick walls. In order to avoid condensation in the stills owing to the radiation of heat from the upper surface, the vessels are protected with a covering of asbestos. The joints are packed with rubber gaskets for hydrochloric acid and with pure asbestos fiber for nitric acid.

The crude acid is first elevated by air pressure from a blow case located where it can be filled conveniently to a storage vessel overhead from which it runs by gravity into the stills, the flow being regulated by a cock so that there will be a slight overflow of the tailings at the farther end of the system. The capacity of the still is about 2500 lb. hydrochloric acid and 4000 nitric acid per twenty-four hours' continuous running.

The condensation of acid vapors on a large scale was also a serious problem, for an efficient condensing system is absolutely essential to the successful working of any still. One of the first efficient condensers invented and patented was constructed of glass tubes and is illustrated in Fig. 4.

It consists of a number of glass tubes 6 or 7 ft. long by 1 in. diameter, and two so-called standpipes made of earthenware or porcelain (the latter especially for chemically pure acids), each about 4 ft. long by 4 in. diameter, having a row of holes along one side as close together as possible and of a suitable size to receive the glass tubes without binding. The standpipes are placed in an upright position and securely fastened in place, having the rows of holes facing each other and at a distance that will allow the tubes to enter far enough to enable the joints to be tightly packed. The acid vapors enter through an opening in the side of one of the standpipes and is divided in its passage through the tubes in which the condensation is effected by trickling cold water on the surface of the tubes supplied from a perforated water pipe placed just above the topmost tube; the water trickles down over each tube in succession and becomes so hot before it reaches the bottom that much of it evaporates, thus increasing the efficiency of the condenser, and what does not evaporate is caught in a trough and carried off. The glass tubes are subjected to the extremes of temperatures where the cold water first strikes, but with a good quality of glass they stand the strain remarkably well, although breakage is not infrequent.

Condensation may also be effected without the use of water, as the heat radiates to considerable extent and causes a current of air which carries off the heat by contact. The cooling effect of the air is, of course, not as effective as that of water, but this deficiency may be made up by increasing the number of tubes. This also removes the danger of breakage experienced when using water, but, on the other hand, it increases the number of joints and the liability of loss from leakage when asbestos is used as a packing.

This condensing system, known as the Hart condenser, from the name of the inventor, has been in successful operation during a number of years as a condenser for both nitric and hydrochloric acids with certain modifications to suit the peculiarities of each acid, which will be referred to later.

The condensing system used by the J. T. Baker Chemical Company is made entirely of porcelain vessels and is illustrated in Fig. 3, previously referred to. The vessels are made practically the same as the porcelain vessels used as stills and are connected together in the same manner for the flow of the acid and the passage of the vapors. The condensation is effected by immersing the vessels in a bath of running water, the flow of the water being regulated so that the water surrounding the vessel into which the hot vapor from the still is entering will not be subjected to too great a change of temperature, otherwise breakage is liable to occur owing to the size of the vessel and the thickness of the walls. There are comparatively few joints to cause trouble from leakage, and they are easy to get at and keep tight. They are used for

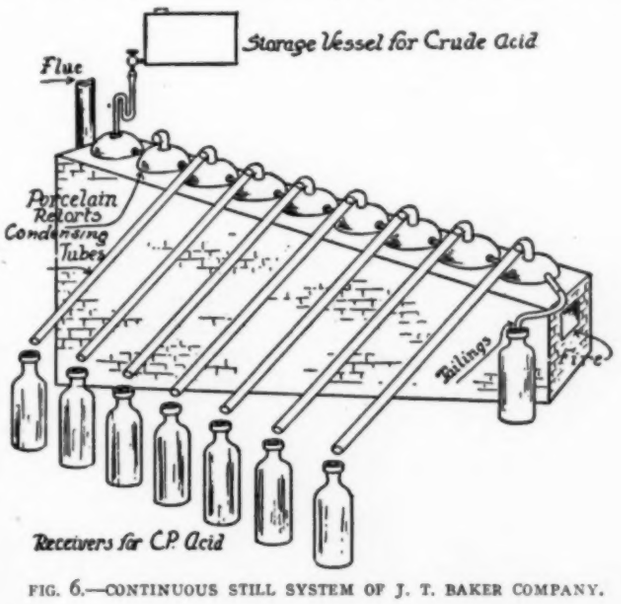


FIG. 6.—CONTINUOUS STILL SYSTEM OF J. T. BAKER COMPANY.

condensing both hydrochloric and nitric acids with some modifications to suit the peculiarities of each acid, the modus operandi of which will next be described.

The distillation and condensation of hydrochloric acid present difficulties which are peculiar to the acid itself and give rise to problems different from distillation processes in general. This is due to the fact that the concentrated acid does not distill at a uniform degree of strength nor at a uniform temperature. The strongest acid commences to distill at a very low temperature and gives off at first dense fumes of dry HCl gas which are uncondensable and must, therefore, be absorbed in water or in a weaker acid. As the distillation pro-

ceeds the temperature rises and the strength of the distillate as well as the remaining liquid decreases until both reach a strength of about 1.10 sp. gr., after which the strength of both, as well as the boiling point, remain constant.

The weaker grades of acid must, therefore, be again concentrated by saturation with the gas from subsequent distillations, and as the absorption gives rise to heat it becomes necessary to change the receivers frequently and allow them to cool in order that the final saturation may be made at a temperature low enough to insure the proper degree of strength. This was the old method of distilling, and, as it was necessary to use comparatively small stills, generally flasks of 2 or 3 gal. capacity, each one connected with a small Liebig condenser, and receivers of about the same capacity, the process involved much

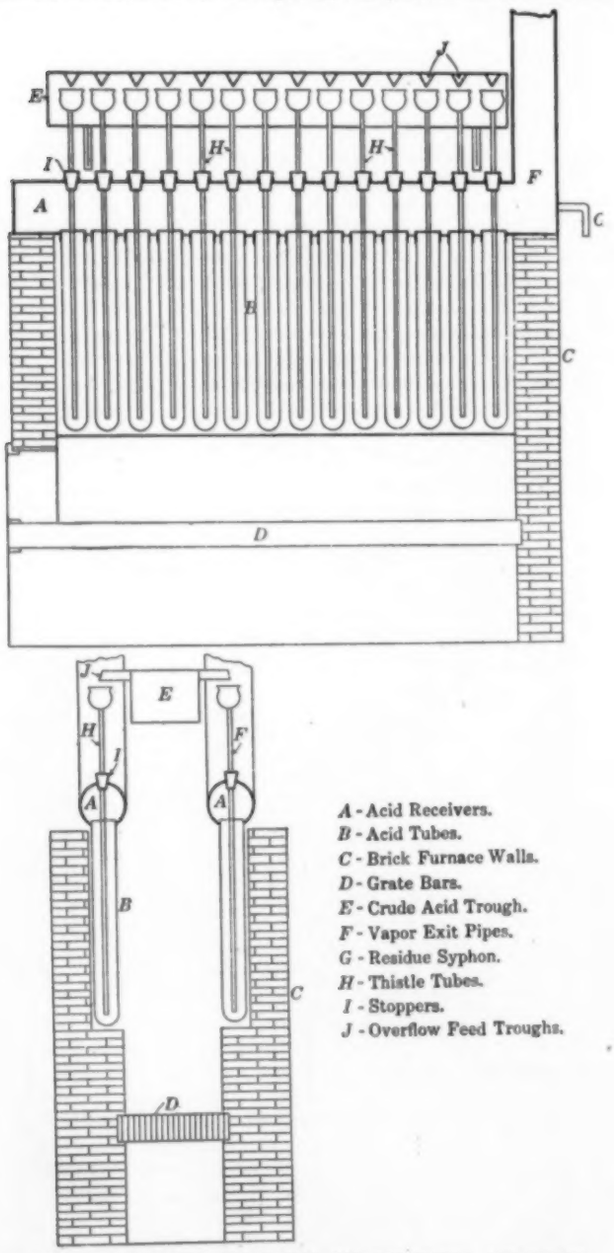


FIG. 7.—IMPROVED APPARATUS FOR DISTILLING APPARATUS.

labor and was far from being economical, particularly when attempting to work on a large scale.

These difficulties were all successfully overcome when the continuously operating system was introduced. In this system the distillation of the strong and the weak acid takes place at the same time and the different strengths passing into the condenser together at once recombine, the gas being absorbed in the liquid simultaneously as the vapors condense, and the acid when it finally leaves the condenser will have the same strength as the acid entering the still. In the first vessel of the distilling system into which the fresh acid enters there is presumably a slight ebullition and dry gas given off, while from each succeeding vessel down to the last ones situated directly over the fire there is more or less moisture given off with a corresponding decrease in the strength of the tailings, the weakest being about 1.10 sp. gr.

In the first vessel of the condensing system into which the vapor enters (referring to the system illustrated in Fig. 3) only the weakest vapors condense, while owing to the temperature of the water surrounding the vessel being almost the same as that of the vapors, the gas passes on into the cooler vessels where it is absorbed by the liquid flowing slowly through them until in the last vessel, which is thoroughly cooled, the gas is all absorbed and the liquid at the same time saturated. The

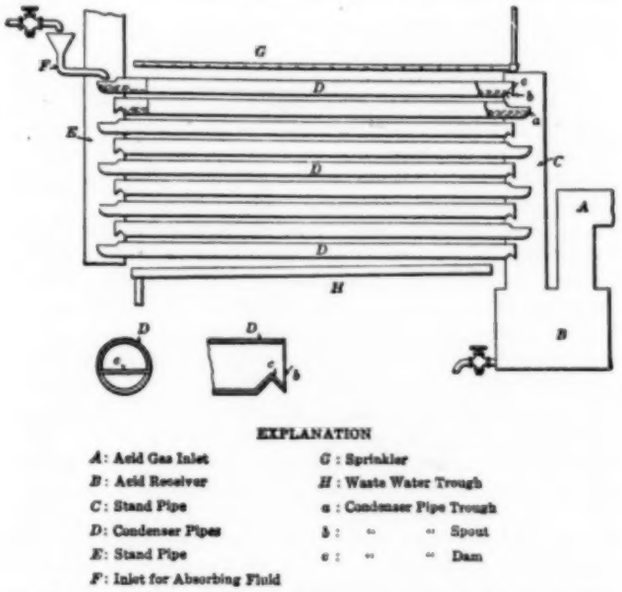


FIG. 8.—HYDROCHLORIC ACID CONDENSER, HART-ADAMSON PATENT.

acid runs by gravity from the last vessel through a jar containing a small hydrometer and enables the operator to keep watch of the strength, which varies according to the proportion of tailings drawn off.

The distillate is usually a little stronger than the original acid owing to the removal of the tailings, for the reason that as the acid entering the still contains, say, 36 per cent HCl, the tailings contain only about 20 per cent, and the difference in the amount of HCl gas is absorbed in the distillate, thereby increasing the strength to that extent. Indeed it is possible, by drawing the tailings off faster, to bring up the strength of an acid which is 2 or 3 deg. below saturation before distillation, but the method is not economical; the best results are obtained by using an acid, say, 1.18 sp. gr. and drawing off enough tailings to bring it up to 1.19 sp. gr., which is the strength generally required by the trade. About 5 per cent in tailings is sufficient for this purpose and this amount is also sufficient to carry off the impurities fast enough when using ordinary commercial hydrochloric acid.

The impurities commonly found in the commercial acid are principally sulphuric acid, iron, sodium sulphate, arsenic, and sometimes sulphurous acid and free chlorine. Before distilling the acid sufficient chlorine is added to oxidize the H_2SO_3 to H_2SO_4, the excess of Cl being reduced by adding some reducing salt in solution. The non-volatile impurities remain in the tailings, and if there is any spurting in the last vessel where they become concentrated or any volatilization of sulphuric

acid at this point, these impurities will be retained in the other vessel without danger of being carried over into the distillate. Arsenic compounds being volatile are always found in the distillate, at least in traces, as it is impossible to obtain a crude acid made in the ordinary way from salt and sulphuric acid which does not contain some of this impurity.

An acid made synthetically from Cl and H as a by-product in the manufacture of caustic potash at Niagara Falls is free from arsenic and a chemically pure acid made by distilling this product after reducing the free Cl, which is always present in great excess, is strictly chemically pure. Organic matter is difficult to remove, as it appears to form a volatile organic chloride which distills over and gives a yellow color to the distillate, although it can then be reduced and removed by a second distillate.

Hydrochloric acid can also be condensed in a glass tube apparatus similar to one above described (Fig. 4) with some modifications; the tubes instead of being open at both ends are closed at one end and an opening made on the upper side when in a horizontal position placed directly under the open end of the tube above, which is provided with a lip, so that when arranged in alternate order the liquid will flow from the topmost tube through each tube in succession to the bottom. In this way the vapors which condense in the tubes follow a long and tortuous passage over which the gas passes and is gradually absorbed, while at the same time it is kept cool by water trickling over the outside. This arrangement is illustrated in Fig. 5, where it is described for another purpose. As an apparatus for absorbing gases it is covered by patents.

In the distillation of nitric acid difficulties are met which are easily overcome by using a continuously operating system similar to that used for hydrochloric acid with some modifications. The impurities commonly present in the crude acid are sulphuric acid and sodium sulphate from the materials used in its manufacture, chlorine and iodine present in the nitrate of soda and hyponitric acid due to a slight decomposition of the nitric acid in the process of manufacture.

The chlorine and hyponitric acid are volatile at a low temperature and will, therefore, be found in the first part of the distillate; the balance of the distillate will, however, contain some hyponitric due to a slight decomposition of the acid giving the distillate a slight yellow color, which can be removed by heating and subsequent exposure to air. In a continuously operating still, such as either of those above described, the volatile impurities are separated by conducting the vapors from the first vessel or two to a separate condenser from that in which the vapors from the remaining vessels are condensed, and instead of allowing the acid to leave the condenser cold, the latter is constructed so that the acid is drawn off hot in order to bleach it without subsequent heating. This is accomplished when using the glass tube condenser, by giving the tubes a slight inclination towards the standpipe into which the hot vapors are entering, and when using the porcelain vessel system, by inclining the bath and reversing the flow of the condensed acid back into the first vessel, in each case forming a sort of reflux condenser. The hot acid thus obtained is led through a bleaching apparatus which also serves as a cooler to reduce the temperature and avoid cracking the receiving vessel. This apparatus is illustrated in Fig. 5.

As previously described it consists of a number of glass tubes constructed so that the acid flows successively through all the tubes and being thus exposed to the air which is carried along with it, the hyponitric acid is oxidized and at the same time the heat is absorbed by trickling cold water on the outside of the tubes in the usual manner. Furthermore, if the acid is above standard strength (sp. gr. 1.42), as is generally the case when crude acid is made solely for redistilling, the strength may be reduced by adding a calculated quantity of distilled water while it is running through the cooler, which also removes the heat thus generated.

This distillation of sulphuric acid presents a more difficult problem than the other acids on account of the high temperature at which it boils. Glass retorts with very thin walls have generally been found the only thing suitable, although it is well known that porcelain vessels have been used in concentrating chamber acid by distilling off the water and bringing it up to a strength somewhat below complete concentration, a process which, of course, does not require a temperature as high as the distribution of the concentrated acid itself.

After experimenting for some time, a method for using porcelain retorts was devised and a continuously operating system of stills made of this ware is now being successfully used by the J. T. Baker Chemical Co. The stills or retorts are made comparatively small and hemispherical in shape, being about 8 inches in diameter across the bottom. On each side are tubular openings of suitable size so that the retorts can be connected together by passing the tubular of one retort into the tubular of the retort next to it. Instead of having the retorts on a level as in the other systems, they are laid on an incline as shown in Fig. 6, so that the acid overflows from one retort into the next below, the position of the outlets being such that the acid stands at the depth of about 2 inches in each retort. The joints are packed with asbestos to prevent the escape of vapors, and the upper parts of the retorts are protected to prevent the radiation of heat.

The fire is located at the lower end of the furnace with a long inclined flue over which the retorts are laid and the waste heat utilized for bringing the acid up to the boiling point before it reaches the point where the distillation takes place. A number of retorts can be placed on one furnace, and from about half of them nearest the lower end concentrated acid will be obtained, the others giving acid containing more or less water. The crude acid is supplied in a steady stream and is regulated so that there is a constant overflow of tailings from the last retort.

The impurities in crude sulphuric acid are principally sulphate of lead and sulphate of iron, and if present in any great quantity will give trouble by forming incrustations on the bottom of the retorts and cause bumping and breakage, unless the retorts are cleaned out at regular intervals of four or five weeks' steady running.

The condensation of sulphuric acid vapors may be effected in glass tubes without using water to absorb the heat, provided the tubes are long enough, say 7 ft. long by 1 in. diameter. Owing to the high temperature of the vapors the strain on the glass is very great, but with a good quality of glass having very thin walls this method of condensation has proved quite successful in the past, notwithstanding that breakage was a frequent occurrence, particularly in cold weather. The condensation, however, was seldom complete and there was more or less escape of acid fumes from the ends of the tubes, while the temperature of the condensed acid was very little below the boiling point, so that the receiving vessels, which were necessarily made of glass, were frequently cracked. The constant escape of irritating fumes and the danger to the operator from handling the hot acid added to the difficulties which made the problem of condensation a serious one.

The introduction of fused silica ware has helped to solve this problem, for owing to its great resisting power to changes in temperature, it is possible to use silica tubes in place of glass and sprinkle them with water. This not only effects a complete condensation of vapors, but reduces the temperature of the distillate to a point at which it can be handled with perfect safety.

* * *

In the discussion which followed Prof. **Edward Hart** spoke of his own work in this field. As to the glass flasks mentioned by Mr. Baker, he said that they found them very unsatisfactory since they broke frequently and required a great deal of coal. In consequence of this he (Prof. Hart) devised the hanging test-tubes (Fig. 2) and they found that one-sixth of the coal formerly used was sufficient.

Prof. Hart thought that the apparatus of Mr. Baker, made of porcelain, would probably not be so economical of coal as the Hart apparatus with the hanging test-tubes. A patent for a modification of the hanging test-tubes has been applied for which is an improvement on the old form. In the old form the circulation in the tubes was very poor, so that sulphate of soda was apt to accumulate and finally break the tube; but this was obviated by the modification shown in Fig. 7, in which A is the acid receiver, B the hanging tubes, J a trough for the supply of acid and H thistle tubes feeding the acid to the bottom of the hanging test-tubes. The object of the introduction in this way is obvious, since the fresh acid is fed to the bottom of the hanging tube and the strong residues containing the sulphate of soda are forced through G. In case of hydrochloric acid the I stoppers are made of rubber.

Dr. F. W. Frerichs said that in the last twenty years he has manufactured large quantities of chemically pure acids, using 5-gallon glass retorts, each retort set in a small iron kettle. Nitric acid simply was distilled. Hydrochloric acid was distilled from crude acid after treating it in such a manner that free chlorine and sulphurous acid would not contaminate the product. They would obtain, at the end of the distillation, a very weak acid which was condensed in large 5-gallon glass receivers, and they ran water over the body of the receivers to effect cooling. Taking weak hydrochloric acid from one operation and saturating it with hydrochloric acid gas coming off first in the following operation, they obtained strong acid. For the manufacture of chemically pure sulphuric acid, they bought weak sulphuric acid 20 Be. coming from platinum stills. Strong acid was obtained by evaporation of pure weak acid. This was a very slow process, but made upwards of 200,000 lbs.

Mr. J. T. Baker said he felt that he owed it to Prof. Hart to say that his inventive genius had been stimulated by the association he had with Prof. Hart. As to the Hart still, he believes it is a very excellent form of still, but owing to the fact that this was covered by patents, he was compelled to make a substitute. Porcelain stills make a very good substitute.

Prof. **Edward Hart** called attention to an ingenious device of Mr. Adamson for the absorption of hydrochloric acid. The arrangement of condensing tubes in this is Hart's. The little dam made in the end of the tube, shown in Fig. 8, is Mr. Adamson's invention. By this simple device the liquid is retained in each tube for some time, allowing a much more perfect absorption than could otherwise be had. They have found this a very efficient apparatus.

In reply to a question by Mr. Minor, whether there is any preheating of the acid, Mr. Baker said that it is not really necessary. It is merely preheated by being in the flue of the fire. The fire does not cover the entire portion of the still. The fire will probably be in the first part and the other tube will be in the flue. They used that in distilling nitric acid, because it could be distilled at a low temperature.

Alloy Research of Bureau of Mines.—The United States Civil Service Commission announces an open competition examination for alloy chemist, for men only (salary ranging from $2,400 to $3,000 per year), and another for junior alloy chemist, for men only (salary ranging from $1,500 to $1,800 per year) in the Bureau of Mines, Department of the Interior. The duties of the former position will consist of "an investigation covering the methods of preparing non-ferrous alloys, the furnaces and other appliances used in their manufacture, and the prevention of waste in their production." The duties of the junior alloy chemist will consist of assisting in this investigation.

The **Braden Copper Company,** of Chili, has given the Hardinge Conical Mill Company an additional and repeat order for twelve more 8-ft. Hardinge pebble mills, making a total of sixteen mills.

British Institute of Metals.

The annual autumn meeting of the British Institute of Metals was held in London on September 25 and 26. The papers presented at this meeting are herewith abstracted.

"The Annealing of Coinage Alloys" was discussed in a paper by Dr. **T. Kirke Rose.**

The softening caused by annealing the pure metals gold, silver, copper, nickel, etc., and the alloys used in coinage was studied with the aid of the scleroscope, an instrument by which the hardness of metals is measured.

The metals and alloys hardened by rolling were annealed at various temperatures for lengths of time, ranging from a few seconds to 16 days. It was found that at moderate temperatures annealing begins almost imperceptibly. As the temperature rises this change is hastened until, at much higher temperatures, metals and alloys revert from the hard to the soft state instantaneously.

For example, pure gold can be softened in about 100 hours at 100 deg. C., in one hour at 150 deg. C., and in a few seconds at 200 deg. C. At lower than 100 deg. C. more time is required. Lead softens instantaneously, and zinc, cadmium and tin gradually at 15 deg.

Alloys generally require a higher temperature for annealing than their constituent metals. Thus, standard gold can be annealed in 16 days at 300 deg., and in a few seconds at 600 or 700 deg. Full details of all the coinage alloys are given.

Softening is accompanied by recrystallization, the large distorted primary crystals in the hardened metal being broken up into microscopic ones. Recrystallization takes place instantaneously if the softening is instantaneous.

The chief practical conclusion to be drawn from the investigation is that the time of annealing may be made very short if the proper temperature in each case is attained.

The paper is illustrated by curves and photomicrographs.

"The Effect of Temperatures Higher Than Atmospheric on Tensile Tests of Copper and Its Alloys" was discussed in a paper by Professor **A. K. Huntington,** summarizing in 32 curves results obtained at various times during the last 12 years.

The range of temperatures given in this paper is restricted to such as might occur during the use of these metals and alloys in the arts, as distinguished from the temperatures at which they are worked.

The method by which the data were arrived at is also described in detail. Very pure electrolytic copper is taken as a standard for comparison, and first of all various copper alloys are contrasted with it. Broadly speaking, the alloys are found to have the same characteristics as the pure copper. Contrary to what might have been expected, copper is the dominating partner. It has a distinct individuality which is modified, but not extinguished, by the other metals. The curves for wrought iron and steel are compared with those for copper, and it is shown that the former are markedly different from the latter.

As a result of having to consider generally only cold tests of iron and steel, engineers are in the habit of reckoning the elastic limit as 50 per cent of the breaking load. It will be seen from the curves given in this paper that this method of estimating the elastic limit is not correct for iron and steel at temperatures above the normal, nor, as a rule, for other metals at any temperature.

It is fairly certain that engineers have hitherto expected a reduction of elongation with an increase in the breaking load in a given metal or alloy. They have been justified in this by the behavior of iron and steel at atmospheric temperatures, and they are still justified at such temperatures, as these metals are used in the arts. That they are not justified in applying this rule to copper and its alloys is manifest from an examination of the curves in this paper.

"Inter-Crystalline Cohesion in Metals" was discussed in a paper by Dr. **Walter Rosenhain** and Mr. **Donald Ewen,** both of the National Physical Laboratory.

The authors accept as the most reasonable explanation of the special strength possessed by the crystal boundaries of metals in a normal condition the existence of an inter-crystalline cementing material, and in their present paper certain experiments and considerations are described which lend considerable weight to their hypothesis that this cementing material consists of the metal itself in an amorphous condition, a conception which has been arrived at by several investigators quite independently. Further, they explain the presence of this amorphous material by assuming that what they term a "crystal unit" depends for its formation on the grouping together of several previously existing "liquid" molecules, and that when two or more crystal systems abut against one another a series of interstices result which are smaller than the "crystal units," and in consequence the liquid in them is unable to take up its crystalline form.

The production of inter-crystalline brittleness in metals by suitable heat treatment and the adaptation of a metal to strain at high temperatures by the abnormal development of the inter-crystalline boundaries rather than by the formation of slip-bands, are phenomena among others which have been observed by the authors in their laboratory, and which are quite consistent with their hypothesis.

Beilby has shown that metal in the amorphous condition is more soluble and generally more chemically active than when crystalline, and it seemed reasonable to the authors to suppose that it might also be more volatile and that if two specimens of metal—one in a finely crystalline form and the other coarsely crystalline—were subjected to the same vacuum and temperature for the same period of time, the former would lose weight more rapidly than the latter, owing to the total area of inter-crystalline boundary being greater. Experiments carried out with silver, copper and zinc, heated in high vacua to temperatures about 100 deg. C. below their melting points have entirely confirmed this expectation, definite and constant ratios of loss of weight per unit area between the coarse and fine specimens being found, thus for zinc of at least 99.8 per cent purity the ratios fine-coarse in three independent heats with the same specimens were 2.25, 2.26 and 2.37. In the case of silver the ratios in five independent heats varied from 1.07 to 1.27.

Photomicrographs of the various metals before and after heating are given, and an appendix on the formation of twinned crystals in silver is added.

"The Effect of Other Metals on the Structure of the Beta Constituent in Copper-Zinc Alloys" was discussed in a paper by Professor **H. C. H. Carpenter.**

The influence of various common metals on the structure of the apparent beta constituent in copper-zinc alloys was determined.

Class I.—Metals insoluble in copper or zinc, viz.: bismuth, lead and chromium. With the exception of one alloy, containing 2.9 per cent of bismuth, their effects on the structural stability of apparent beta were found to be very slight, and the conclusion is warranted that the percentage of lead and bismuth ordinarily present in industrial alloys are entirely without influence.

Class II.—Metals of somewhat limited solubility, viz.: iron, antimony, tin, aluminium, silicon and vanadium. With the exception of iron, all these metals aid the precipitation of alpha-gamma visible at low magnifications from apparent beta. They displace the alloy from the eutectoid composition, and shift it to the gamma side. Consequently gamma crystallites are produced, leaving a matrix of alpha. Iron is very much slower in its action, and up to about 2 per cent is without effect. It forms a connecting link between Classes I and II.

Class III.—Metals of great solubility, viz.: nickel and manganese. Nickel is somewhat irregular in its action, but behaves like the majority of the metals in Class II, whereas manganese is almost without action of this kind.

The metals iron, chromium and manganese have only a slight influence on the temperature of the beta to alpha + gamma inversion. No metal has been found capable of lowering this transformation below the ordinary temperature.

The problem of making beta the stable phase at the ordinary temperature appears to be theoretically insoluble. Practically, however, the structural stability of apparent beta can be strengthened by keeping down the impurities in copper-zinc alloys to a minimum.

Provided that such alloys are not heated in use their stability will last practically for an indefinite period.

"The Structural Resolution of the Pure Copper-Zinc Beta Constituent Into Alpha Plus Gamma" was discussed in a paper by Professor **H. C. H. Carpenter.**

The beta structure of the pure alpha plus gamma eutectoid alloy may be regarded as absolutely stable. It cannot be upset by any annealing, however prolonged, and in this respect it appears quite unique.

Repeated quenchings of this alloy in liquid air undoubtedly produce structures characteristic of a two-phase system. These structures, however, are of a transitory nature, and the conditions of their appearance are also obscure. They do not appear to correspond to a segregation of alpha plus gamma in a coarse crystalline form.

Between 460 deg. C. and the ordinary temperature the alloy was found to undergo no other inversion detectible on a cooling curve.

Ultimately the resolution of the pure beta structure into alpha plus gamma was brought about by the "nucleus" action of an eutectoid alloy containing 0.95 per cent of vanadium, which contains its alpha plus gamma in a coarse crystalline form immediately after being cast. By infecting the pure apparent beta alloy with this substance for a short period at 420 deg. C., followed by a prolonged annealing, coarse segregations of alpha and gamma were obtained.

A lamellar resolution of pure beta was never observed.

"The Influence of Oxygen on the Properties of Metals and Alloys" was discussed in a paper by Mr. **Edward F. Law,** dealing with the question of oxides occurring in metals and alloys. The subject is viewed from a general standpoint and is not confined to any particular metal or alloy.

It is pointed out that the existence of these oxides is usually ignored inasmuch as they are not determined in the ordinary course of chemical analysis, and they frequently escape detection by mechanical tests. Nevertheless, they play an important part in the behavior of the metals when in service, and the author contends that they are all the more dangerous on account of the ease with which they may escape detection by the ordinary methods of testing.

Instances are cited of the failure of bearings, the fracture of copper fireboxes and other troubles caused by the presence of oxides. Attention is particularly directed to the influence of oxides on the corrosion of metals, and the author states it as his opinion that experimental work on corrosion which does not take into account the presence of oxides in the metals experimented upon is of little value.

"The Joining of Metals" is discussed in a paper by Mr. **A. E. Tucker.**

The author shows that whereas metals used often to be joined by riveting or folding, these processes are now largely replaced by autogenous welding and other recently introduced means. Methods of joining metals by physical processes, such as welding and brazing, give rise to some interesting considerations, and the physical process involved in such operation, and the commercial application of these operations are detailed in the paper.

The author discusses the phenomena of cohesion and adhesion, stating that when high heats are used cohesion would appear to act, but it is well known that fusion is not required for affecting the union of several metals to bring about a joint having a great degree of strength.

The methods in practical use for joining metals are shown to be by metallic cement, such as tinman's or brazing solder, by autogenous fusion, or by the use of a cementing material under pressure.

The soldering of aluminium has always presented considerable difficulties, and Mr. Tucker discusses this question in detail. He states that if the two surfaces of aluminium are cleaned with a certain flux and an alloy (solder) containing a high percentage of aluminium, with such addition of any metal as will reduce its melting point slightly below that of pure aluminium, is used, it is possible to obtain a satisfactory joint that will stand even the hot steam test.

Other processes dealt with in the paper include autogenous fusion; the oxy-acetylene process; the use of aluminium powder; arc welding and resistance welding, and the manufacture of compound sheets.

"Autogenous Welding by Means of Oxygen and Acetylene of Copper and Its Principal Alloys, and of Aluminium" was discussed in a paper by Professor **F. Carnevali.**

The author describes a series of experiments on a subject of considerable practical importance nowadays, namely, the oxy-acetylene welding of copper, brass, bronze and aluminium. The paper is illustrated by a number of photographs of actual welds and weld fractures, as well as of microphotographs highly magnified in order to illustrate the structure of the welded metals.

Dr. Carnevali shows, in the case of copper and its principal alloys, that rapid heating and sudden fusion of the metals subjected to welding profoundly modify their physical and mechanical properties, developing within them strains and structural alterations which are detrimental to the metal. In the case of copper there is an average reduction of 50 per cent in the capacity to resist fracture, and an increase of about 30 per cent in brittleness, while the percentage of ductility is reduced to about a tenth of the original. In the case of bronzes and brasses it has not been found possible to determine the extent of the deterioration in the mechanical properties, but this deterioration increases as the number of constituents of the alloys subjected to welding are increased. In the case of alloys made up of several constituents, these may be improved after welding by a suitable heat treatment, thus relieving the internal strain set up by the sudden temperature changes involved in the process of welding.

The author maintains that the oxy-acetylene welding of copper and its principal alloys has a practical application limited to those parts of machinery which are not of large dimensions, and which are not subjected to severe mechanical stresses.

As regards the autogenous welding of aluminium, the author observes that the sudden heating and rapid fusion of the metal subjected to the welding process alters the physical and mechanical properties in a manner analogous to that noticed in the case of copper, but to a less degree. The structural modifications principally take the form of coarse crystallization of the metal. His experiments show that both by hammering and by reheating to 450-500 deg. C. the homogeneity of the weld-zone is increased; also that whenever aluminium contains small quantities of other elements easily oxidized at high temperatures, e.g., copper, the oxidization of the metal by fusion is facilitated; also the inclusion within it of granules of oxide detrimental to the mechanical properties of the weld-zone.

Carried out with the necessary precautions, the oxy-acetylene autogenous welding of aluminium is held by Dr. Carnevali to be capable of extensive practical application, especially for the autogenous welding of small machine parts.

"Oxygen in Brass" is discussed in a paper by Professor **T. Turner.** Brass ingots which have been poured at too low a temperature, and metal which has been rolled and annealed, are sometimes brittle and unsatisfactory owing to the presence of oxygen. This oxygen does not appear to be dissolved in the metal, nor to exist in the form of a eutectic, as is the case with copper and copper oxide. Oxide of copper cannot exist in melted brass, as it is immediately reduced by zinc with the formation of oxide of zinc. Oxide of zinc appears to be insoluble in brass and in zinc. The action of the oxide of zinc in spoiling the mechanical properties of brass, appears, therefore, to be merely that of a foreign brittle body or powder which prevents the particles of brass from coming into metallic contact with each other.

The estimation of oxide of zinc in brass presents special difficulties. Experiments are described which show that the methods adopted for the determination of oxygen in copper are not suitable for brass. A ready and accurate process is still required by chemists employed in connection with brass manufacture.

"The Influence of Impurities in 'Tough-Pitch' Copper, with Chief Reference to Antimony," is discussed in a paper by Mr. **F. Johnson.**

In continuation of a series of experiments carried out with a view to ascertaining and placing on record the varied influences of traces of impurities on the useful properties of copper, the author has presented the results of experiments which have been directed toward the determination of the influence on copper of antimony, and, to a lesser degree, of lead and tin.

The experiments have dealt mainly with the modification of the physical and mechanical properties of "touch-pitch" copper brought about by the presence of the above-mentioned impurities. The presence of a certain critical quantity of oxygen is shown in some cases to be absolutely essential to insure good hot-working properties. The following are the conclusions given by the author as a result of the investigation:

1. Antimony up to 0.5 per cent has no detrimental influence on the hot-forging qualities of "tough-pitch" copper free from other impurities. It is even possible successfully to forge copper containing 1 per cent antimony if sufficient oxygen be present.

2. In copper which has been "overpoled," antimony tends to mitigate the phenomenon of "spewing" during solidification.

3. "Tough-pitch" arsenical copper (0.4 per cent arsenic) is slightly hardened for hot-rolling by the presence of antimony (0.2 per cent), but otherwise its mechanical properties are slightly improved.

4. The mechanical properties of "tough-pitch" pure copper after rolling and annealing are but little altered by small additions of antimony. The tensile strength is slightly raised, and the elongation is lowered. The slight gain in toughness is probably traceable to the greater soundness of the case ingot.

5. With regard to the structural condition of antimony in "tough-pitch" copper, it exists in two forms: (a) Partly in solid solution (probably as dissolved Cu_3Sb). (b) Partly as an insoluble compound with oxygen (slate-colored "oxidules"). Oxygen in excess exists as cuprous oxide (light blue "oxidules"). The latter, together with the antimonial "oxidules," form a ternary eutectic with the solid solution.

6. The addition of lead to pure copper or arsenical copper causes the surface of a "tough-pitch" ingot to sink during solidification. Further poling with the object of obtaining a level surface is attended by the risk of rendering

the metal "red-short." Like antimony and arsenic, lead tends to check "spewing."

7. The mechanical properties of arsenical copper (0.4 per cent arsenic) at normal temperature are little affected by the addition of lead (0.2 per cent).

8. The addition of tin (0.2 per cent) to "tough-pitch" arsenical copper is attended by an increase in hardness during hot and cold rolling, and an increase in tensile strength. The elongation is correspondingly lowered, but the toughness is unimpaired.

The Possibilities of a Potash Industry in the U. S.

Papers read before the Eighth International Congress of Applied Chemistry

The Production of Available Potash from the Natural Silicates

Abstract of paper read before the Eighth International Congress of Applied Chemistry.*

By ALLERTON S. CUSHMAN and GEO. W. COGGESHALL.

There is an enormous supply of feldspar in the United States, both east and west, which could be made a source of potash supply, provided the cost of production is low enough to compete with the potash-holding manure salts which are at present so largely imported from Germany. Although the imported potash salts are richer in potash than any product that can ever be made from American feldspar, yet the crude German manure salts contain large quantities of chloride and sulphates of elements which are not only undesirable in the fertilizer, but which may do actual harm under certain conditions. It is this fact which gives encouragement to the attempt to produce from American feldspar a straight potash fertilizer which could be used in exactly the same way that hardwood ashes have been found useful.

The natural silicates commercially available as sources of potash are chiefly orthoclase and leucite. Both of these minerals are potassium-aluminium silicates. The theoretical formula for orthoclase is written $K_2O.Al_2O_3.6SiO_2$ and for leucite $K_2O.Al_2O_3.4SiO_2$. The principal sodium feldspar, albite, has the theoretical formula: $Na_2O.Al_2O_3.6SiO_2$. It is well known that these feldspars run into and substitute each other in various proportions so that the products from different quarries will vary widely in respect to their soda and potash contents.

Six General Lines of Research.

Six general methods have been proposed for decomposing the natural silicates in order to obtain potash salts soluble in water.

I. Adaptation of Natural Agencies like the action of moisture, of carbonic acid gases, etc. In the slow processes of nature these agencies are known to have a decomposing or kaolinizing action upon feldspar.

In 1904 Blackmore (U. S. Patent 772,206) proposed the action of carbon dioxide gas under 500 lb. pressure upon a cream of the ground mineral, repeated intermittently for several hours, in the attempt to produce a yield of carbonate of potash. Ten years earlier the same experimenter (U. S. Patent 513,001) had proposed using lime, calcium chloride and steam pressure in an autoclave to produce chloride. In 1910 Coates (U. S. Patent 947,795) proposed the addition of bacteria for the decomposition of feldspar. In 1910 Carpenter (U. S. Patent 959,841) proposed to heat the mineral intensely and cool suddenly by plunging in water, in the effort to render the feldspar amorphous, in the hope of making it more available for plant growth. None of the above processes have as yet been shown to possess industrial possibilities.

II. Wet Processes of a Chemical Nature.—Levi in 1904 (French Patent 344,246 and English Patent 13,875) and Piva in 1905 (French Patent 351,338) proposed methods for treating leucite by means of solutions of alkali or alkali earth hydrates, generally under increased pressure. The same general method for treating feldspar was claimed by Swayze in 1907 (U. S. Patent 862,676) and by Gibbs in 1909 (U. S. Patent 910,662).

Also Gibbs in 1904 (U. S. Patents 772,612 and 772,657) proposed a process of treatment with hydrofluosilicic acid, and subsequently with sulphuric acid, in order to produce potassium sulphate. In 1907 Cushman was granted U. S. Patent 851,922, a public patent which proposed the sludging of finely ground feldspar with water, the addition of a small amount of hydrofluoric acid and electrolyzing the mixture in wooden cells provided with wooden diaphragms. Under this process both potassium and aluminium hydrate passed through the cell diaphragm into the cathode compartment. This process, although perfectly practical, has not yet been made commercially possible owing to the high cost of hydrofluoric acid and the large amount of by-products formed in the process. None of the above processes have as yet been made commercial possibilities.

III. Dry Processes of a Chemical Nature, in which the Potash Salts are Volatilized.—In processes of this nature, fluxes, and in some cases fuel, for reducing purposes is ground and mixed with the feldspar, the mixture being subsequently heated until the potash salts are volatilized and collected either in the stack dust or partially collected from the gases by passing them through or over water. Swayze in 1905 (U. S. Patent 789,074) heated ground feldspar with gypsum and carbon, and proposed to collect the volatilized sulphate. Spencer and Eckel in 1909 (U. S. Patent 912,266) made a cement mixed with calcareous and silicious fluxes and green sand, a natural potash-bearing iron silicate, clinkered the mixture in a rotary cement furnace, and obtained a Portland cement, at the same time collecting the potash in the stack dust and the flue gases. In 1911 Eckell (U. S. Patent 1,011,172) proposed a somewhat similar method but heated only high enough to drive off the potash salts and not high enough to clinker the mixture. Again in 1911 Eckel (U. S. Patent 1,011,173) melted a mixture of green sand, limestone and fuel, tapped off the melted iron and slag, and recovered the potash salts from the flue gases.

Some of the processes under this heading have been tried on a large scale. No great difficulty is recorded in driving off the potash in the furnaces, but obstacles were encountered in the attempt to collect the potash from the gases. As a by-product operation in the manufacture of cements, these processes may yet come to be of some industrial importance.

IV. Dry Processes which Propose to Separate Potash as Hydroxide or Carbonate.—The old method of Bickell, proposed in 1856 (U. S. Patent 16,111), which depended upon heating a mixture of feldspar, lime, and natural phosphate rock or guano to a bright red heat, has not as yet been proved practical or successful. The process of the Soc. Romana Solfati in 1905 (French Patent 352,275), which proposes the roasting of leucite with carbonate, hydrate or nitrate of soda and lime and subsequently the passage of steam through the product to produce sodium aluminate and potassium carbonate, is possible from a chemical standpoint, but the high cost of operation has not permitted the process to come into commercial use.

*The full paper is printed in Vol. V of the *Original Communications* of the Congress, page 33.

V. Dry Process Producing the Chloride.—These processes have been most experimented with upon the mill scale of operation.

In 1900 Rhodin (U. S. Patent 641,406) and in 1901 (J. Soc. Chem. Ind., XX, 439) proposed fritting feldspar with lime and salt. According to the published results, this experimenter obtained good yields, although the process has not become a commercial success. In 1907 McKee (U. S. Patent 869,011) suggested heating a potash-bearing material containing mica with lime, salt and carbon in order to obtain a yield of potassium chloride. Cushman in 1911 (U. S. Patent 987,436) proposed mixing feldspar with lime and salts of a mineral acid capable of decomposing the silicate, giving the mixture special treatment previous to heating in a rotary furnace in order to produce the chloride. This method has been tried out on a large mill scale of operation, and the results obtained are discussed below.

VI. Dry Processes Producing Sulphates.—In 1911 Thompson (U. S. Patent 995,105) proposed heating to a bright red heat a mixture of feldspar, sodium acid sulphate, and sodium chloride and subsequently leaching out the potassium sulphate produced. This experimenter claims that potassium chloride is first formed, which is subsequently changed to the sulphate by the action of the acid sulphate. It is stated that this process has recently been tried on a commercial scale of operation. Sodium acid sulphate is a by-product that is reasonably cheap, although a large quantity is not available. The lack of an abundant supply of acid sulphite is perhaps the greatest drawback to the commercializing on a large scale of this process, although it is possible that it may still become of some industrial importance. Hart in 1911 (U. S. Patent 997,671) proposed to fuse feldspar with some barium compound, such as the sulphate, together with carbon, to pulverize the cool melt and subsequently to digest the product with sulphuric acid and thus produce in solution potash alum and a residue of barium sulphate and silica which is claimed to be useful as a paint pigment. Hart claims that some of the potash is volatilized during fusion. Since the fusion temperature is 1500 deg. C., it is probable that a considerable portion of the potash does volatilize, and it is possible that this difficulty may interfere with the commercial success of the process.

Wadman in 1907 (U. S. Patent 847,856) proposed heating lepidolite with potassium sulphate and leaching the product with sulphuric acid in order to obtain sulphates of lithium and potash.

The authors conclude that the most promising processes for making potash available from the natural silicates on a commercial scale of operation appear those which are conducted in the dry way, but without actual fusion of the reacting mixture.

Large-Scale Test of Cushman-Coggeshall Process.

The process which seemed to the authors most promising of successful adaptation to commercial ends is that of Cushman (U. S. Patent 987,436) coupled with the method of preparation of the materials before furnacing proposed and developed by Coggeshall (U. S. Patent 987,554).

This process has recently been given extensive trials on a large scale and interesting results have been obtained. The process consists essentially in powdering 100 parts of potash feldspar rock together with about 20 parts of lime and with or without 10 to 20 parts of rock salt. This powdered mixture is fed to the top of a moving drum about 3 ft. in diameter, in a layer about half an inch deep.

As soon as the layer is formed a strong solution of calcium chloride is applied from a series of small tubes. The $CaCl_2$ at once unites with the lime forming a so-called oxy-chloride cement and a large portion of the mixed powder is thereby at once formed into the "clumps" or aggregates lying in a bed of surplus powder. As the drum revolves the bed is removed by a scraper to a belt which delivers the mixture to a screen which separates the clumps from the residual powder. The powder is returned by a screw conveyor and elevator to the hopper above the drum again. The clumps are about the size of peas and pass from the screen directly to a rotary kiln similar to those used in burning Portland cement. The kiln is heated by a blast of air and powdered coal in the usual manner.

The clumps pass regularly down through the increasingly heated portions of the rotating kiln and roll out at the end, practically without alteration in size and shape.

A large percentage of the total potash present in the feldspar is converted into potassium chloride during the heat treatment, and very little is volatilized. The dry clumps are of a pale yellow color outside, due to the iron in the ash of the bituminous coal used, but they are snow-white inside. The clumps are finally ground, producing a pale yellow material containing as much water-soluble K_2O as hardwood ashes, although the potash is in the form of chloride, and the product also contains considerable free lime. Up to the present time no attempt has been made on a large scale to leach out the soluble potash. The ground material is being given field tests as a straight potash fertilizer containing lime.

Résumé of the Large Scale Experiments.—Potash feldspars were obtained from five different localities. Eleven carloads were used in the trials, amounting to a total of 385 tons. Each carload was ground and analyzed separately. The lowest in potash ran 6 per cent K_2O and 3 per cent Na_2O, the highest 11.3 per cent K_2O and 3.1 per cent Na_2O. The bulk of the spar ran 10 per cent potash and 2 per cent soda, and the results given in this paper were obtained on the 10 per cent spar.

The lime was a high calcium quicklime, running about 90 per cent CaO and 5.6 per cent MgO.

The salt was rock salt from New York State and ran about 98 per cent NaCl.

The calcium chloride was obtained from the Solvay Process Company. It was in the solid form and contained about 75 per cent $CaCl_2$ and 25 per cent water.

All of the above materials are available in very large quantities and at low cost. The calcium chloride is a by-product in the form of a moderately strong solution, and but a small portion is concentrated at the present time, as the chief use is for refrigeration purposes. Vast quantities are now run to waste. The solid form was used in these trials merely for convenience.

Many heats were made with mixtures of varying proportions, but the two mixtures used in the work here described were:

Feldspar,	100	Feldspar,	100
Lime,	20	Lime,	20
Salt,	10	Salt,	20

The feldspar, lime, and salt were separately crushed in gyratory crushers and rolls, and dried in a rotary drier. In continuous work the proper mixture would be made at this point by continuous weighing machines, but as a number of different mixtures were to be tried, each of the three raw materials was ground separately in Huntington mills and put into bins. This preliminary grinding of the feldspar and salt was to about 65 per cent through a 100-mesh sieve, and that of the lime about 83 per cent through the 100-mesh. The weight per cubic foot of each powder of the above fineness was then ascertained and measuring boxes were built so that the materials could be separately measured out and run together into a large mixing machine. Almost a ton was thus mixed each time. The mixture was then conveyed to a tube mill and further ground to a fineness of from 97 per cent to 99.5 per cent through a 100-mesh sieve, and then conveyed to the bin over the clumper and kiln.

The calcium chloride masses were broken up and thrown on a perforated grid in a large tank holding about 48 tons. Water was run in and the chloride dissolved most readily. The solution was run out when about 42 deg. Beaumé into two large sump tanks, and brought to a constant strength of about 42 per cent $CaCl_2$. This was then pumped up to an elevated tank

and piped from there, through a constant-level tank, to the dropper tubes of the clumper placed in a row above the drum. This drum is 15.5 ft. long and 3 ft. in diameter, and is horizontal. There are fifteen valved pipes, each one feeding an adjustable pipe holding thirty-eight short dropping tubes of brass 1-16 in. internal diameter, and set 5.16 in. apart.

The finely ground mixed powder is taken from the bin by a chute, elevator and screw conveyor and distributed in a long hopper trough over the drum. It is taken from the trough by a roll device and spread evenly on the moving drum at its topmost point. The drum has a surface velocity of about 1.6 inches per second, the layer of powder advancing at this rate.

It was found that by dropping the liquid very rapidly upon the powder, the clumps could be made rapidly enough to give a full feed to the short rotary kiln when only one-third of the trough and droppers and drum is used. A clumper drum 5 feet long produces every hour almost two tons of fresh clumps and considerably over a ton and a half of burned product with the kiln used in these trials. The excess of powder passes through a screen and goes to the same elevator which lifts the original material from the bin. The amount of actual $CaCl_2$ in the fresh lime is regulated to about 20 parts to each 100 parts of feldspar in the mixture. The clumps leave the screen in rounded form and flow directly into the kiln.

The Rationale of the Chemical Engineering Operations.

The reason for the above procedure will now be explained. In the first place, calcium chloride reacts very efficiently under these conditions with the feldspar by replacing the potassium with calcium, thus forming calcium silicate and potassium chloride. Anhydrous calcium chloride is expensive to produce and it is impracticable to grind it into a mixture on a large scale on account of the rapid absorption of moisture. Even if such a dry mixture could easily be made, its use would present certain disadvantages.

When a reaction between an ore and solid fluxes is produced by heating up to the fusing temperature, then reaction takes place on the surface of the particles alone and only at the points where the ore is in actual contact with the flux particles. Finer grinding will produce a larger surface area and thus a greater number of actual contact points, leading to a larger yield. There is, however, a degree of fineness beyond which it is not wise to go, on account of the cost of extremely fine grinding.

Another factor in the problem is brought out by the following experiments. A batch of ore and the theoretical amount of solid flux were ground together to just pass a 50-mesh sieve. This powder, when subjected to a certain heat treatment, gave a reaction yield of about 35 per cent of the theoretical. The mixture was then ground to just pass a 100-mesh sieve and given the same heat treatment. A reaction yield was obtained of about 65 per cent of the theoretical.

The mixture was then ground to pass a 200-mesh sieve and again reheated as before. A smaller yield was obtained then when the material just passed the 100-mesh, although the particles were undoubtedly only half the average diameter with about four times the surface area and should therefore have had far more points of contact.

Upon weighing equal volumes of 50-mesh, 100-mesh powders, it was found that the latter contained far less material and it became apparent that the 200-mesh powder consisted for over 54 per cent of its volume simply of voids. Such finely ground powders are well known to "surge," that is, to show the tendency to flow like water through orifices in a manner resembling fountains. Material ground as fine as this is the cause of much trouble at spout slides and conveyors. Each particle of a material of this extreme fineness is undoubtedly surrounded by a film of air, the actual contact with the surfaces is lessened and friction almost eliminated. When allowed to flow into a bin, such a powder assumes an almost horizontal surface, there is practically no angle of repose. Unquestionably the lessened contact caused the low yield in the finely ground mixtures.

Some of the finer material was briquetted and the subsequent heat yield about 85 per cent of the theoretical. Briquetting is, however, expensive and usually necessitates the addition of a binding agent foreign to the reaction.

Clumping Process.

As a result of these investigations, the method was developed for aggregating fine powders by dropping a suitable liquid upon an excess of the powder in such a way as to cause a temporary bond to form, thus practically eliminating the air films or voids around the individual particles and permitting actual surface contact. Under these conditions, with the same ore and flux used in the experiments described above, the same heat treatment yielded within 3 per cent of the theoretical quantity present.

This method of aggregating finely powdered materials previous to furnacing has already been used in several different ways. For example, in an ore mixture in which the fluxing material is an alkaline carbonate, such as sodium or potassium, which forms crystalline salts containing water of crystallization, if the carbonate is used in the partially anhydrous condition and ground with the ore water alone dropped upon the mix in the manner described formed at once a crystalline carbonate which binds the particles of ore and flux into separate clumps, which are hard enough to withstand screening, while the air films are practically eliminated. Using such a mixture and process as this, a practically theoretical yield was obtained, although the flux was used only in the exact molecular proportion called for by the reaction.

By this clumping process a very intimate contact of reaction of surfaces is readily obtained at a low cost. The quantity of flux necessary to complete the reaction is greatly reduced, the duration and temperature of the heat treatment is lessened and working with rotary kilns dusting and stack losses are almost entirely eliminated. The clumps are beautifully adapted to the feed mechanism of rotary kilns, as they flow easily, do not dust and take the heat more evenly than fine powders. Now that the temperature conditions in rotary kilns can be accurately controlled, it would seem that many chemical and metallurgical reactions which are now performed by intermittent processes and with low yields could be much more economically carried out in continuous rotary kilns, taking advantage of this new method of forming aggregates previous to furnacing.

In the application of this method to the treatment of feldspathic rock, advantage was taken of the fact that a solution of calcium chloride acts upon dehydrated lime to form the oxychloride which is a strong cementing compound. It was found that the formation of calcium oxychloride gave a sufficiently strong bond to enable the aggregates to withstand the operation of screening and the burden in the kiln.

The theoretical quantity of calcium chloride flux required depends upon the total quantity of K_2O and Na_2O present in the mix, as it is evident that the soda must also be liberated in proportion to its content. The feldspar ore used ran 10 per cent K_2O and 2 per cent. Na_2O which required theoretically 15.5 parts of calcic chloride.

In all the trials some slight excess of calcium chloride has been used. The strength of the solution and the method of treatment has been such that about twenty parts of actual calcium chloride are present in the fresh clumps to every 100 parts of feldspar. The twenty parts of lime used is for the purpose of forming the aggregates, and this lime remains practically unchanged in the finished product. The presence of lime in a potash fertilizer will be found advantageous to most soils, and it is generally admitted that lime increases the manurial value of a fertilizer.

If the object was to leach out the soluble potash salts from

the product, a much smaller amount of lime could be used without interfering with the formation of hard clumps. The salt is added because it has been found to aid the heat reaction, probably mechanically as will be explained later on. The fresh clumps contain from 16 to 20 per cent of moisture, which is, of course, evaporated in the upper part of the kiln.

Treatment in the Rotary Kiln.

The rotary kiln used in these trials was one of the old bottle-shape cement kilns with a total length of slightly over 55 ft., the upper 20 ft. having a diameter of 4 ft. clear inside the firebrick lining, the lower portion widening out to nearly 6 ft. inside diameter. The pitch was ⅞ in. per foot and the most suitable speed was found to be one revolution in about 2½ minutes.

The conditions of the heat treatment are very important. The kiln used was too short to yield the best results, and after the preliminary experiments changes were made which caused the material to take about 1½ hours to pass through the length of the kiln. The temperature of the gases issuing from the upper end of the kiln were read continually with a thermo-couple pyrometer fitted with a 15-ft. fire end and temperatures were also taken from time to time at the firing platform.

A furnace wall temperature of about 1370 deg. C. is required for efficient burning of powdered bituminous coal. This is, however, much too high a temperature for potash work in a rotary kiln. This difficulty called for experimental investigations and adjustments of the heat treatment before the proper yields could be obtained. If a longer kiln had been available, there is every reason to believe that a more efficient use of the heat could have been obtained. The coal used was fairly high volatile bituminous coal. It was ground to about 94 per cent through a 100-mesh sieve and blown into the furnace under an air pressure of about 10 lb. per square inch.

During the progress of the clumps down the kiln the following reactions probably take place. At the entrance to the kiln the water begins to evaporate. As the hotter zone is approached, the temperature rises high enough to melt calcium chloride and salt. Whether the calcium chloride is free to melt is not known to the authors, as the exact composition of the oxychloride compound formed has not yet been determined. The results of their work seem to prove that the reacting chlorine is more readily evolved from the oxychloride compound than it is from calcium chloride alone. The melting of the salt, however, continues the bond of the reacting particles, causing them to thoroughly "wet" each other, and from this point on the attack on the silicate proceeds rapidly. During the heating usually from 1 to 2 per cent of Na_2O is volatilized.

When operating with no salt present, the yield of soluble potassium chloride was 47.5 per cent of that originally present in the feldspar. On adding to the mixture ten parts of salt to each 100 of spar, a test heat yielded 64 per cent, but of this 9 per cent was lost by volatilization, giving a yield of 55 per cent net in the final product. On adding twenty parts of salt to the mixture the yield grows to 69.2 per cent with no volatilization and to 75 per cent under heat conditions which caused a volatilization of 7 per cent, leaving a net yield of 68 per cent of that originally present.

In the case of clumps made from a mixture of 100 parts of feldspar containing 10 per cent K_2O and 2 per cent Na_2O, twenty parts of lime, twenty parts of salt and twenty parts of calcium chloride, the theoretical composition if no volatilization loss takes place is shown compared with the actual results obtained in the following table:

	Theory	Analysis	
Total K_2O	6.25%	5.8%	
Water soluble K_2O	.....	4.2%	Equals 6.65% KCl
Loss of K_2O	.....	.5%	As KCl already formed
Total Na_2O	7.62%	7.1%	52% made into NaCl
Water soluble Na_2O	6.37%	5.1%	Showing 1.79% vaporized as NaCl or 26% of that present

This particular product contained 11.2 per cent of free lime and total lime by analysis 15.5 per cent. There was also in this sample about 5 per cent of free unchanged calcic chloride. The amount of calcic chloride in the various runs made up to the present time have been reduced gradually to about 1 per cent., and it is felt that in the future better conditions of heat treatment will make complete use of the calcic chloride and at the same time raise the yields of soluble potash. In later runs in which only ten parts of salt were present in the mix, the theoretical and actual analysis of the product was as follows:

	Theory	Analysis	
Total K_2O	6.66%	5.62%	
Water soluble K_2O	.....	4.5%	Equals 7.12% KCl
Vaporization loss of soluble K_2O	.....	1.04%	As KCl already formed
K_2O insoluble in water	.....	1.12%	
Total Na_2O	4.15%	.....	
Water soluble Na_2O	.....	3.7%	Showing 0.45% vaporized as NaCl or 11% of that present

This product contained 12.25 per cent of free lime, the total potash rendered soluble was 5.54 per cent of the product or 83.2 per cent of the total quantity present, but as 15.6 per cent had been volatilized the net yield in the product amounted to 57.6 per cent.

The material which was later made continuously according to the process described above carries 4.5 per cent of water soluble K_2O in the form of 7.12 per cent potassium chloride and in addition to this material carries only 1.12 per cent K_2O insoluble in water. It is well known that a 2 per cent citric acid solution will extract, when used according to the Wagner method soomewhat more K_2O than can be made directly water soluble. This fact is of considerable interest when the product is to be used directly as a potash fertilizer.

Conclusions—Cost of Process.

"It is believed that under better conditions of heat treatment which can be obtained with longer kilns and with a somewhat different arrangement of the combustion chamber, that slightly better yields than those reported can be obtained. It should be remembered that the kiln used in these experimental trials was originally designed for burning cement, but this type of kiln has long been superseded by improved forms. In order to get the proper heat treatment in the middle of the kiln to complete the reaction, it was necessary to have the upper part too hot. This condition will not maintain in a properly designed kiln. It is also believed that the use of oil as fuel would have allowed an easier regulation of the heat treatment but the trials so far undertaken have been made under conditions which were found available at the time.

"The subject of the costs of this process and of the product can not be gone into in detail at this time, but a few general statements may be made. The production of water-soluble potash in feldspathic rock is essentially a low-grade proposition, and the commercial success of such a process depends upon the low cost of the various operations. The manufacture of a straight potash fertilizer containing as valuable ingredients only potash and lime must be carried out on a very large scale and by the most modern methods of continuous operation. With regard to the clumping process, the trials have shown that this operation can be practically carried out as a continuous process and at an exceedingly low charge per ton of product.

"The process may be directly prepared with that of the manufacture of Portland cement. It is a little easier to grind feldspar and lime than the shales and limestones used in cement manufacture. Drying will cost no more. Chemical control of the raw mixes will not be more expensive and perhaps much less. Clumping, as has been shown, adds a very small charge to the expense of treatment. The cost of furnacing the feldspar mix will be less than similar charges in the cement industry, as the temperatures required are much lower and less coal is consumed. The product from the potash kiln is comparatively soft and pulverizes easily in hammer mills, while the charges on the cement industry for grinding

clinker is an important item. Again the softer potash product merely requires to be ground fine enough for use as a fertilizer, whereas cement clinker must be ground very fine and costs rise rapidly with increasing fineness. Repair bills in the case of feldspar treatment should be much smaller than in cement manufacture. The charge for raw materials is somewhat larger than in the case of cement but this is more than met by the smaller costs of operation.

"The potash fertilizer as now produced should be the equal in fertilizing value of the ordinary grades of hardwood ashes. The product carries practically the same content of water-soluble potash and somewhat more lime than wood ashes. There is every reason to believe that if the process becomes an industry the yields of the water soluble potash can be considerably improved. The material yielded is not a fused product, it is friable as an ash and it has the physical texture to make it a valuable aid to soil structure. The success of the product, must, of course, depend upon the results obtained under test conditions in its experimental use as a fertilizer. If results are obtained which are as good or better than those which usually attend the proper use of high grade wood ashes, it is believed that there should be no reason why this product cannot be successfully produced and introduced, especially in those parts of the country where potash feldspars, fuel and shipping facilities are available."

* * *

The Extraction of Potash from Silicate Rocks.

An abstract of a paper read before the Eighth International Congress of Applied Chemistry.

By WILLIAM H. ROSS.

The potash-bearing minerals of the United States may conveniently be divided into three classes, as follows: (1) Alunite and similar minerals; (2) the greensand marls, and (3) the igneous rocks.

(1) *Alunite* is a hydrated sulphate of aluminium and potassium. It differs from the minerals of the other two groups in that the potassium is readily available by simple ignition of the mineral to a dull red heat. (Waggaman, Circular 70, Bureau of Soils.) When occurring in sufficient quantity and purity alunite is thus a possible economic source of potash and has long served as a source of potassium alum in Italy and other countries. Its occurrence in this country is limited to comparatively small deposits in Utah, Colorado and Nevada.

(2) *Greensand*, or glauconite, is essentially a hydrated silicate of iron and potassium, but it is extremely variable in composition and never occurs pure. It is formed through the interaction of various alteration products, and organic matter is believed to play a part in its formation, which would explain its occurrence in the marl deposits of Kentucky, New Jersey, Tennessee and other states. Like the minerals of the third group it is a refractory silicate, and the potash which it contains is not readily available.

(3) The potash-bearing *igneous rocks* are among the most widely distributed minerals and occur as constituents of nearly all rocks. The principal minerals of this class from the point of view of the potash which they contain are orthoclase, or microcline, muscovite, and leucite. Millions of tons of rock containing one or more of these and related minerals with a potash content in the neighborhood of 10 per cent are to be found widely distributed all over the globe. It is for this reason that the igneous minerals, particularly the potash feldspars, are most often spoken of as a source of potash salts.

In Table 1 is given sample analyses of the most important potash-bearing minerals.

The desirability of finding some economical way of extracting potash from these minerals has long attracted the attention of various investigators and numerous patents have been issued covering processes which are claimed to solve this difficult problem.

The increasing yearly demand for potash salts in connection with artificial fertilizers has of late renewed interest in this direction, and in some cases companies have been organized for the purpose of manufacturing potash by one or other of the various processes which have been proposed, but up to the present no potash prepared in this way has been placed on the market.

TABLE I.—ANALYSES OF POTASH-BEARING MINERALS.

	(1)	(2)	(3)	(4)	(5)
SiO_2	0.22	51.56	65.87	44.39	50.23
TiO_2	.....	.....	.....	.....	2.27
Al_2O_3	37.18	6.62	19.10	35.70	11.22
Fe_2O_3	Trace	15.16	.....	1.09	3.34
FeO	.....	8.33	.....	1.07	1.84
MgO	.....	.95	None	.....	7.09
CaO	.....	.62	.20	.10	5.99
Na_2O	.33	1.84	2.56	2.41	1.37
K_2O	10.46	4.15	12.24	9.77	9.81
H_2O	12.99	10.32	.64	5.88	2.65
P_2O_5	.58	.....	.....	.....	1.89
SO_3	38.34	.....	.....	.....	.74
Fl	.....	.....	.....	.42	.50
Other constituents	.....	.....	.....	.....	1.68
	100.10	99.55	100.61	100.83	100.62

[1]Alunite from Marysvale, Utah. Selected Specimen. Analysis by W. T. Schaller, Bull. U. S. Geol. Survey, No. 511, p. 8.

[2]Glauconite from greensand marl. Hanover Co., Virginia. Analysis by M. B. Corse and C. Baskerville, AM. Chem. Jour., 14,627.

[3]Ground commercial feldspar from quarry of J. B. Richardson & Sons, Bedford, Ont. Analysis by George Steiger, Bull. U. S. Geol. Survey, No. 420, p. 9.

[4]Muscovite from Auburn, Maine. Analysis by R. B. Riggs, Bull. U. S. Geol. Survey, No. 419, p. 286.

[5]Leucite-bearing rock, Wyoming. Analysis by W. F. Hillebrand, Bull. U. S. Geol. Survey, No. 512, p. 11.

Practically all methods yet proposed, in principle at least, have been covered by patents. A comparative study was therefore undertaken by the author of all processes for which patents have been allowed, with a view of finding what methods, if any, give promise of being practicable commercially.

In the present paper the results so far obtained are given.

Modifications of J. L. Smith Analytic Method.

The most convenient way of determining the alkalies in silicate rocks is the well known J. Lawrence Smith method. According to the directions usually given for this method, 0.5 gram of the ground material is mixed with an equal weight of pure ammonium chloride and 4 grams of calcium carbonate. On igniting the mixture gently at first, the ammonium chloride is volatilized and part of the calcium carbonate is converted into calcium chloride. These two compounds of calcium when heated at a temperature of about 1000 deg. C., with feldspar, or other silicate rock, bring about its decomposition, and any potash present is converted quantitatively into potassium chloride. The same result is obtained if the proper amount of calcium chloride is used instead of ammonium chloride in the first place.

Of the many patents which have been issued for extracting potash from silicate rocks, at least four may be considered modifications of the J. Lawrence Smith method, since the essential feature of each consists in heating the potash-bearing material with calcium carbonate and some metallic chloride.

I. The first of these, United States patent No. 513,001, was issued to *H. S. Blackmore* in 1894. To produce a soluble potassium salt according to this patent, orthoclase, reduced to a fine powder, is mixed with finely powdered calcium chloride in about equal proportions to the potassium silicate present. To the mixture is then added an excess of calcium oxide and a sufficient quantity of water to render the entire mass moist. This is introduced into a sealed furnace, or retort, and heated to a temperature of about 1100 deg. C., whereby the water mixed with the mass is converted into superheated steam at a high pressure, which is supposed to assist materially in the transformation of the orthoclase into soluble potassium chloride and insoluble silicates of calcium and aluminium. The heating is continued for about two hours, and, after cooling, the mass is placed in vats and lixiviated.

The part of the process as patented which requires the moist mass to be heated in a sealed furnace to a temperature of 1100 deg. C. could obviously not be carried out on a large scale, for it would not be feasible to make a furnace which would stand the pressure produced at this temperature.

II. In 1900 United States patent No. 641,406 was granted to *G. J. Rhodin* for obtaining soluble potassium salts from feldspar. In carrying out the process according to this invention, 1 part of feldspar is mixed with 1 part of lime, and 0.2 part of sodium chloride, all in a finely powdered condition. The mixture is then heated in a closed vessel of iron or other material, or else in an open-hearth or blast furnace to a bright yellow heat and maintained at that temperature for a considerable time, care being taken not to melt or fuse the mixture. The cooled mass which still remains in a powder may be applied directly as a manure, since the potash present is claimed to be rendered available by the treatment, or it may be separated from the mass by treatment with acids.

III. In 1907 United States patent No. 869,001 was issued to *Ralph H. McKee* for a process for producing potassium compounds from potash-bearing material containing mica by essentially the same treatment as that covered by Rhodin's patent for the extraction of potash from feldspar.

IV. United States patent No. 987,436 was granted to A. S. *Cushman* in 1911 for a method for obtaining potash from silicate rocks. According to this method the feldspathic rock is reduced to as fine a subdivision as possible and mixed with finely powdered quicklime in the proportion of 100 parts of the rock to 20 parts of lime. The mixture is then spread on a suitable conveyor, as belt or drum, in the form of a bed having a thickness from ⅜ to ½ in. To the surface of this bed is now applied a solution of calcium chloride in separate drops, and of such a concentration that the amount of calcium chloride added should be sufficient to supply chlorine in quantities at least molecularly equivalent to the total alkali contained in that portion of the feldspar which becomes aggregated into lumps on the addition of the solution. The aggregates, which harden quickly at ordinary temperatures, are separated from the unconverted powder by screening, and are then heated in a rotary kiln at a temperature preferably, but not necessarily, below the point at which a substantial part of the potassium chloride is sublimed.: The product is discharged continuously from the furnace in lumps and may be crushed for use directly as a fertilizer; or the potassium chloride may be extracted by means of water and recovered from the solution, or utilized therein in any preferred way.

From a comparative study which was made of these patents it does not appear that the use of sodium chloride has any advantage over calcium chloride. The latter is a by-product obtained in large quantities in the manufacture of sodium carbonate, and is somewhat more effective than the former in bringing about complete decomposition of the feldspar, but when limited amounts of the reagents are used, a somewhat larger amount of the potash is rendered soluble with the use of sodium chloride than with calcium chloride. . . .

While a considerable portion of the potash was rendered available when using approximately the proportions of the reagents stated in the patents, the total potash in the feldspar was not rendered soluble in this way at the temperature specified. Thus, when 1 part of feldspar is ignited with 1 part of calcium carbonate and 0.25 part of calcium chloride, which is 0.05 part in excess of that equivalent to the alkalies in the feldspar, only about 60 per cent of the potash in the feldspar is rendered soluble. Increasing the proportions of calcium carbonate and calcium chloride used produces a comparatively small increase in the amount of soluble potash obtained, and complete decomposition of the feldspar only takes place when 1 part is ignited, under the conditions of the experiment, with about 1 part of calcium chloride and about 2 to 3 parts of lime. When this proportion of the reagents is used, considerable variation in the temperature of ignition will give the same results, and almost the entire amount of the potash is rendered soluble at a temperature below the melting point of potassium chloride. . . .

Unless a large excess of calcium chloride is used, when ignited with feldspar and lime, no vitrification takes place on heating to a temperature up to 1050 deg. C. The ignited mass remains in the form of a powder, and consequently the soluble material present can be readily leached out without the necessity of any previous grinding of the mass. The same statements hold true when sodium chloride is used, but with a more limited variation in the proportions of the reagents which may be taken. Thus, a hardened mass is obtained when 1 part of feldspar is ignited to 1050 deg. C., and with 1 part of calcium carbonate and 0.25 part of sodium chloride, but if the proportion of calcium carbonate is doubled the mass remains in a powdered form. When calcium chloride is used, the mass does not harden on ignition, even with 1 part of calcium carbonate.

On account of its simplicity, the method of decomposing feldspar by heating with calcium carbonate and with calcium chloride (or sodium chloride) could undoubtedly be carried out on a large scale without involving any serious mechanical difficulty, and the method would thus be a practical one providing the value of the products obtained would compensate for the expense involved. Although pure feldspar may be obtained which contains upward of 15 per cent potash, the average grade of feldspar which could be mined on a large scale would undoubtedly contain less than 10 per cent. If potash be quoted at 66 cents a unit (estimated from prices quoted by the German Kali Works) then the potash in a ton of feldspar containing even 10 per cent of this constituent would be worth only $6.60 when converted into a soluble form. It is thus evident that the value of the potash alone will not compensate for its extraction by this process, or by any modifications of it for which patents have been granted; nor is it at all likely in view of the comparatively low percentage of potash in all silicate rocks that any process can be derived which will prove so simple that the value of the potash alone will pay for its extraction. It seems safe to say, therefore, that any method to be economical must produce at the same time other products of value in addition to the potassium.

Portland Cement as a By-Product.

One of the first patents on a process for converting the insoluble potash in feldspar into a soluble form was issued in 1856 to Charles Bickell (U. S. patent 16,111). The process consists in heating in a reverberatory or other suitable furnace to a light-red heat for about 2 hours 1 part feldspar, 0.5 part phosphate of lime, and 3 or 4 parts of lime, all in a finely divided state. According to the patent the potash becomes available by this treatment, and may be extracted in a caustic state by lixiviating with water, or the mass may be used directly as a manure.

At first sight this process seemed particularly attractive, for if both the potash and phosphoric acid were rendered available by this treatment, as claimed by the patent, the method might be an economical one, since when used as a fertilizer no separation of the constituents would be necessary, and the mixture would be of value for its phosphoric acid as well as its potash content.

It was found, however, that the calcium phosphate has a passive effect in this treatment of the feldspar, and that no greater decomposition was produced in this way than when it was heated with calcium carbonate alone.

Thus when 1 gram of feldspar, 0.5 gram of calcium phosphate, and 3 grams of calcium carbonate were mixed and ignited for two hours at 1000 deg. C., in a J. Lawrence Smith crucible, the amount of potash rendered soluble only amounted to about 2 per cent of the feldspar. The amount of soluble potash obtained when 1 gram of feldspar and 3 grams of calcium carbonate were ignited in the same way, likewise amounted to approximately 2 per cent, but in each case the

greater part of the residue remaining after extracting with water was decomposed when treated with dilute hydrochloric acid, the potash going into solution.

When the temperature was increased to about 1200 deg. C., the soluble potash amounted to 5 per cent of the feldspar, and the extracted residue was then found to be readily and completely decomposed by hydrochloric acid. From this solution was obtained the remaining portion of the potash which did not dissolve on digesting with water.

The crucible in which these ignitions were made was closed with a cap, and as this end of the crucible was not ignited, there was little tendency for the potash to escape, but when the ignition was made in an open platinum dish in a furnace at a temperature of about 1400 deg. C., the potash in the feldspar was found to have been completely lost by volatilization.

In carrying out this experiment the feldspar was first dried to constant weight by heating in a muffle furnace at 1000 deg. C. The calcium oxide used was likewise reduced to constant weight by igniting chemically pure calcium carbonate at a temperature of 1400 deg. C., for several hours. One gram of the feldspar and 1.68 grams of calcium oxide, equivalent to 3 grams of calcium carbonate, were then well mixed and ignited in an open dish in the furnace at 1400 deg. C., for one hour. The weight of the mixture was found to have decreased by 0.1606 gram, which is equal to 16 per cent of the feldspar. The residue was then analyzed for potassium, but only a trace was found.

The experiment was then repeated, using ten times the amount of feldspar and a corresponding amount of calcium oxide. The same care was taken as before to reduce each constituent to constant weight before mixing. After igniting for one-half hour the loss in weight of the mixture amounted to 1.3912 grams, equal to 13.9 per cent of the feldspar. On repeating the ignition for one hour a further loss in weight of 0.1630 gram took place, which was increased to 0.1768 gram on igniting for one hour longer, making a total loss of 1.5680 grams, equal to 15.7 per cent of the feldspar. Since the feldspar was shown by analysis to contain 15.9 per cent of $K_2O + Na_2O$, it would thus appear that the greater part of the alkalies in the feldspar were driven off in the form of oxides. This was confirmed by an analysis of the residue, which contained less than 0.2 per cent of total alkalies.

The hardened mass remaining after ignition strongly resembled cement clinker, and that the product obtained by igniting feldspar and lime together contains all the essential elements of a cement is well known. Using commercial feldspar and lime in the proportions of 1 to 3, a clinker approaching the composition of Portland cement is obtained, providing the feldspar does not contain an excessive amount of free silica. . . .

In order that a clay may be suited for the manufacture of cement it should have a percentage ratio of silica to alumina of from 3 to 1 to 4 to 1. The ratio of these two constituents in feldspar is 3.5 to 1. In muscovite and leucite of theoretical composition the proportion of silica to alumina is less than 3 to 1, but in commercial samples of leucite-bearing rocks the ratio is usually greater than 4 to 1.

A clinker of the same ultimate composition as that which results when feldspar and lime are heated together may also be obtained when part of the lime is replaced by sufficient calcium chloride to be equivalent to the potash and soda in the feldspar, the total calcium used remaining the same as before. In carrying out this experiment the feldspar and lime were ignited to constant weight as already described, and the calcium chloride thoroughly dried by heating in an aid bath below its melting point. Ten grams of the feldspar were well mixed with 2.0050 grams of calcium chloride and 15.7895 grams of calcium oxide, and the mixture then ignited in an open dish in the furnace at 1400 deg. C. By this treatment the alkalies are volatilized as the chlorides. On igniting for one-half hour the weight lost by the ignited mass amounted to 2.5632 grams, equal to 25.63 per cent of the feldspar. When expressed as the chlorides the percentage of alkalies in the feldspar used amounted to 25.82 per cent. It would appear, therefore, that practically the whole of the alkalies in the feldspar were volatilized during the first half hour of ignition. On continuing the ignition for one hour longer the additional decrease in weight which took place amounted to only 0.0090 gram. The residue was then analyzed for potassium and chlorine, but only a trace of each was found.

This shows that the volatilization of the potash in feldspar takes place more rapidly when part of the lime is replaced by calcium chloride than when the feldspar is ignited with lime alone, but in each case the ultimate composition of the residue obtained is the same. Any excess of calcium chloride used above that equivalent to the potassium in the feldspar is slowly decomposed at the temperature at which the ignitions were made, leaving behind the oxide of calcium.

Since the clay used in making cement contains in some cases as high as 3 or 4 per cent of potash, it might be expected that part would escape from the kiln and be collected with the flue dust, particularly in those plants where the Cottrell process for collecting dust has been installed. This has been observed by several investigators to really take place, and the potash then collected is found to be in the soluble form. By the substitution of feldspar for clay in the manufacture of cement the potash then collected would, no doubt, be greatly increased, but since the analyses of cement show the presence of alkalies, it follows that with the style of kilns now in use all the potash in feldspar could not be made available in this way. That a larger proportion of the potassium would be volatilized by substituting for a part of the lime sufficient calcium chloride to be equivalent to the potassium is evident from the experiments already referred to, and experiments are now being undertaken on a large scale to compare the practicability of this procedure with the simple ignition of feldspar and lime alone.

According to the census report for 1910 the Portland cement manufactured in the United States during the year 1909 amounted to 65,000,000 barrels, or 13,000,000 tons, valued at approximately $53,000,000. The maximum quantity of potash which it would be possible to obtain by the use of feldspar in the manufacture of this quantity of cement can be calculated if the potash content of the feldspar is known. This varies up to about 16 per cent., but if half of this, or 8 per cent, be taken as the average percentage of potash in commercial feldspar then 1 part of feldspar combined with 3 parts of lime, equal to 1.68 parts of calcium oxide, would yield 0.08 part of potash and 2.6 parts of cement. Therefore 13,000,000 tons of cement would produce 400,000 tons of potash. Again, quoting potash at 66 cents a unit, this would have a value of $26,400,000, which is three times the value of the potash salts used in this country during the year referred to and about twice the value of the imports for 1911.

Whether or not this would cover the cost of the feldspar, its transportation, and the expenses incident to the recovery of the potash can only be determined by experimentation on a large scale, but the probability that potash salts can thus be obtained in large quantities as a by-product makes this method of getting at the potash in feldspar quite promising.

Bureau of Soils, Washington, D. C.

* * *

The Salines of the United States as a Source of Potassium Salts.

A paper by **J. W. Turrentine,** of the Bureau of Soils of the Department of Agriculture of Washington, D. C., divides the salines of the United States into four groups and gives for each group the results of a determination of their contents of potassium salts.

First, Rock Salts.—Immense deposits of rock salt underlie portions of New York, northeastern Ohio, the southern peninsular of Michigan, Kansas and parts of Louisiana and Texas. In New York, Michigan, Kansas and Louisiana the deposits are entered by shafts and the salt is removed by mining methods.

Also, in these regions and in northeastern Ohio the salt is recovered by solution methods.

The analyses show that the rock-salt of these deposits so far exploited contain but very small amounts of potassium salts. As the history of these deposits is unknown, as is likewise the nature of the brine from which they were crystallized, it is impossible to say whether there is any likelihood of segregations of potassium salts underlying or overlying them. From all theoretical considerations it appears quite improbable that the known deposits of rock salt of the United States east of the

Table I. Brines From Remnants of Desiccated Lakes.
Results in per cent. of total salts

No. Sample	Source	Description	K_2O
1	Searles Lake, San Bernardino Co., Cal.	Average of 7 analyses	6.73
2	Railroad Valley, Nev.....	Average of 19 analyses	6.25

Rocky Mountains are associated with potassium salts other than those small amounts occluded and absorbed during the crystallization of the sodium chloride.

Second, Natural Brines (Subterranean).—They are found in the porous strata underlying numerous areas in the United States, but are utilized for the manufacture of salt on a commercial scale, principally in southern Ohio, West Virginia, and Michigan.

These natural (subterranean) brines, being less pure solutions of sodium chloride, contain more potassium than the artificial brines. But in no instances of the author's analyses do the artificial or natural brines, or the concentrates thereof, contain sufficient potassium salts to make them of commercial value as a source of potash. This is especially true in view of the fact that from none of the systems represented by the brines and mother-liquors can other than double salts of potassium be separated by simple evaporation processes.

Third, Salt Lakes.—Salt lakes and their desiccated remains are found in the arid and semi-arid regions of the western parts of the United States. The lakes are of widely varying degree of salinity, some of them being practically saturated solutions; while others have gone almost to complete dryness and are represented by brine-impregnated saline and alluvial deposits; and the nature of their saline contents varies widely, depending, among other things, on the nature of the rocks constituting their drainage area.

"The brines from the western desert basins present interesting commercial possibilities. Among the large number of brines from those regions analyzed by this bureau the two reported in

Table II. Bitterns From Sea-Water
Results in parts per thousand

No. Sample	Source	Description	K	KCl
11b 198	Leslie Salt Refining Works, San Mateo, Cal.....	From mother-liquor pond.....	8.2	15.6
11b 199	Leslie Salt Refining Works, San Mateo, Cal.....	From different parts same pond.....	13.4	25.5
11b 200	Leslie Salt Refining Works, San Mateo, Cal.....	From salt - making pond.....	13.2	25.2
11b 201	Oliver Salt Works, Mt. Eden, Cal.....	Represents accumulation of 5 years..	14.6	27.8
11b 202	Oliver Salt Works, Mt. Eden, Cal.....	.....	21.5	41.0
11b 204	California Salt Co., Alvarado, Cal.....	Represents 3 years' accumulation.....	35.0	66.7
11b 205	Pioneer Salt Co., San Francisco, Cal.....	Represents 1 year's accumulation.....	11.8	22.5

table I show largest content in potassium salts. The possibility of obtaining from them useful by-products enhance their commercial value.

Fourth, Ocean Brines.—Ocean brine constituted a source of potassium salts before the development of the Stassfurt deposits. Potassium chloride was obtained from the mother-liquors resulting in the manufacture of salt from sea-water by means of solar evaporation.

On the Pacific coast of the United States there are a number of manufacturers engaged in the preparation of salt from ocean water by means of solar evaporation or a combination of solar and artificial evaporation. The mother-liquors resulting have found no very important use, though, for the most part, they are preserved.

When the bitterns from sea-water are evaporated to dryness, it is seen from table II, a mixture of salts is obtained which contains sufficient potassium salts to make the mixture of value as a so-called "manure salt." However, the amounts in which these mother-liquors are produced are so small, that the amount of "potash" obtainable from them is inconsiderable when compared with this country's total annual consumption.

* * *

Distillation of Kelp.

A paper by **J. W. Turrentine,** of the Department of Agriculture, of Washington, D. C., gives an account of an experiment on the destructive distillation of kelp on a laboratory scale in a rotary still designed by John W. Hornsey.

The destructive distillation of kelp for the recovery of valuable distillation products and the extraction of potassium salts from the unvolatilized residue was first proposed by Stanford in England and more recently by Balch in this country. These processes, together with other proposed methods of utilizing kelps, have been discussed in Appendix Q, of Senate Document, 190, 62nd Congress, 2nd Session, which is a report on the "Fertilizer Resources of the United States."

The charge distilled in the author's experiment consisted of two samples of the Pacific kelp, *Macrocystis pyrifera.* These had been dried until their moisture content was 2.89 per cent. (= ave. of 2.67 per cent and 3.12 per cent.) The distillation continued until the evolution of distillation products had practically ceased.

Analyses of the gas samples taken at frequent intervals are given.

The liquid portion of the distillate, yet to be examined, consisted of a watery and an oily portion.

The coke resulting, representing 50.10 per cent of the weight of the original kelp, was light and porous. Its analysis showed it to contain 77.79 per cent potassium chloride. On the basis of this analysis, it is evident that from the three kilograms of kelp distilled, 751.5 grams potassium chloride were obtained.

* * *

Alunite as a Source of Potash.

A Congress paper by **W. H. Waggaman,** of the Bureau of Soils, Department of Agriculture, describes laboratory experiments on alunite as a possible source of potash.

Alunite is a double sulphate of potassium and aluminium which on heating, first gives off water and sulphur trioxide, leaving a residue consisting largely of potash alum. Upon increasing the temperature this latter compound decomposes with a further evolution of the oxides of sulphur, the final residue being chiefly potassium sulphate and alumina. In the author's experiments the oxides of sulphur began to come off at 520 deg. C. At 700 deg. C. the final decomposition of the alunite takes places.

The ignited final residue was analyzed both for potash and sulphur. It contained 15.95 per cent K_2O and 15.37 per cent SO_3, or 1.83 per cent over and above that combined as K_2SO_4.

Alunite has been used heretofore for the manufacture of potash alum (Guyot, *Comptes Rendus,* Paris, 95, 693-694, 1001-1003; Thorp, Outlines of Industrial Chemistry, p. 259,260). Either by heating to 400 deg. or 500 deg. C. and leaching out the alum thus produced, or by ignition at a higher temperature and subsequently treating the ignited residue with sulphuric acid and potassium sulphate.

The production of potassium sulphate and alum by ignition of alunite, and the collection of the evolved oxides of sulphur

by absorption in some suitable medium are covered by French patent No. 419,854.

In this patent, however, it is stated that the decomposition should not be carried to the end, but that the ignited residue should contain both potash alum and potassium sulphate, a separation of which can be afterwards made by lixiviating the residue and crystallizing the solution thus obtained. Although no reason is given why the decomposition should not be carried to an end it is probably on account of the residue, which it is claimed after lixiviation is an excellent artificial bauxite. The average price of natural bauxite in 1910, according to the figures of the U. S. Geological Survey, was $4.89 per ton.

Unless the alunite used is very pure it is doubtful if the leaching out of the potassium sulphate is economical. The experience of the author has been that an enormous volume of hot water is required to entirely free the ignite residue from soluble salts. The subsequent evaporation of this water is both tedious and expensive.

The author figures that from 1 ton (2000 lb.) of pure alunite the following products could be obtained:

Potash (K_2O), 220 lb., at 4 cents per lb.....	$8.80
Sulphuric Acid (52 deg. B.), 1090 lb., at $6 per ton....	3.27
Alumina, 740 lb., at $4.89 per ton.....	1.81
	$13.88

From an economic standpoint it would seem more practical to use the ignited alunite (free from soluble aluminium compounds) directly as a fertilizer either alone or in mixed goods, since the expense of separating the soluble salts from the alumina would probably more than counterbalance the value of the alumina obtained. (The complete paper is published in the *Original Communications* of the Congress, vol. 15, p. 375.)

* * *

The Congress paper by **Edward Hart,** Easton, Pa., describing a process for the simultaneous production of potash, silica, and alumina from feldspar, was published in full in our issue of September 12, p. 634 (*Original Communications* of the Congress, vol. 2, p. 117).

* * *

A paper by **B. E. Curry** and **T. O. Smith,** of Durham, N. H., on a "Study of Soil Potassium" points out that a large amount of potassium fertilizer is not used profitably at the present time.

The effect of such salts as sodium chloride, sodium nitrate, sodium carbonate and acid phosphate is to greatly increase the solubility of the soil potassium. The reaction between these salts and the soil is chemical. Calcium carbonate, calcium sulphate, and calcium oxide have practically no effect on the solubility of soil potassium.

In many cases nitrate of soda alone produces yields as good as are obtained with a combination of nitrate of soda and potassium salts. This may be due to the effect of the nitrate of soda on the soil potassium.

From a practical point of view little profit can be expected from the use of potassium fertilizers for the production of hay. (*Original Communications* of the Congress, vol. 7, p. 51.)

* * *

A paper by **W. O. Robinson** and **W. H. Frey,** of the Department of Agriculture, on "The Use of Ground Rocks and Ground Minerals as Fertilizers," reaches the following conclusions:

Numerous field and pot experiments hitherto performed have proven that orthoclase and potash mica are not efficient potash fertilizers. At present prices the insoluble potash of orthoclase and muscovite costs more than the soluble potash of the Stassfurt salts.

Orthoclase and muscovite are present in American soils in such amounts that any economic application is, figuratively speaking, only a drop in the bucket, and surely can produce no more than proportionate yields. (*Original Communications* of Congress, vol. 7, p. 215.)

How and Why Smoke Is Injurious.

BY RAYMOND C. BENNER, PH.D.

Dwellers in a district where soft coal is burned almost universally condemn smoke. Its injurious effects are well known in a general way. When, however, it comes to certain definite injuries done by smoke and wherein it is harmful, we find that it is not a matter of common information and, furthermore, that it has been made the subject of but comparatively few scientific studies and those not co-ordinated in the different branches.

Soot is, generally speaking, the solid matter given off during the incomplete and faulty combustion of soft coal and consists, for the greater part, of carbon, mineral matter (ash), tar and moisture, together with smaller portions of the sulphur acids (H_2SO_4, H_2SO_3, H_2S), nitrogen compounds, and occluded gases.

FIG. 1.—BUILDING IN PROCESS OF CLEANING IN BUSINESS SECTION OF PITTSBURGH. THIS BUILDING IS CLEANED ONCE A YEAR.

This composition varies between the widest limits, depending upon many factors, such as coal, air supply, temperature of furnace, etc. The following analysis of soot, made by Cohen and obtained under different conditions, shows to a certain degree, the effect of some of these factors.

FIRE PLACE.

	Original coal.	Soot 5 ft. from grate.	Soot 35 ft. from grate.
Carbon	76.80	36.45	37.22
Hydrogen	4.90	3.51	3.51
Tar	0.88	34.87	40.38
Ash	1.80	5.09	4.94

BOILER CHIMNEY.

	Original coal.	Ordinary grate fuel.	Boiler flue.	Base.	70 ft. from base.	Top of 110 ft. chimney.
Carbon	69.30	40.50	19.24	16.66	21.80	27.00
Hydrogen.	4.89	4.34	2.71	0.86	1.44	1.68
Tar	1.64	25.91	0.09	0.28	0.80	1.14
Ash	8.48	18.16	73.37	75.04	66.04	61.80

It will be seen by comparing the analyses given, that the percentages of tar and carbon are higher in the soot obtained by burning coal in a fire place than when it is burned under the boiler. This is due, for the most part at least, to the fact that the temperature of combustion is much higher in the boiler furnace than in the grate and other domestic installations.

The higher percentage of ash in the soot from the boiler furnace can be accounted for on the same grounds. It is a well demonstrated fact that the losses due to the solid combustible

matter in smoke are small, the economy accompanying the proper smokeless combustion of coal being obtained by the complete oxidation of the carbon monoxide, the visible gases, etc., which always accompanies the incomplete combustion of coal. Sir Roberts-Austin found, as a mean of some forty experiments, that 6 per cent of the coal is lost when the coal is burned in domestic grates, while on the other hand Scheurer-Kestener found the loss to be only 0.5 to 0.75 per cent, when burned under the boiler, where the temperature of combustion is higher.

Among the minor constituents of soot the sulphur acids are by far the most important. The amount and kind formed depend upon the factors determining the composition of the soot in general. The following analysis of soot by Cohen and Herford gives an idea of the possible distribution of the sulphur.

Passing out as SO_3, SO_2.....	71.78 per cent	60.00 per cent
Absorbed by soot	14.51 per cent	11.88 per cent
Left behind in ash	13.71 per cent	28.13 per cent

The amount of free acid in soot may be quite large, Russel, having found 4.6 — 4.3 — 7.8 per cent free H_2SO_4 while Cohen and Ruston do not report as large amounts. They find free acid to the extent of 1.62 per cent. Arsenic is also frequently present, but only in small percentages, usually less than 0.1 per cent.

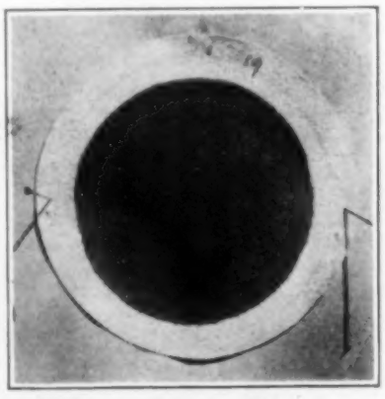


FIG. 2.—A PIECE OF FILTER PAPER THROUGH WHICH THE VOLUMES OF AIR BREATHED BY A MAN IN 24 HOURS HAS BEEN FILTERED.

The nature and composition of soot make it the worst possible kind of dirt. It is black, in fact it is the lamp black that forms the basis of black paints. Its power of absorption is great, giving it the property of occluding large quantities of injurious gases. The tar contained gives the soot the power of firmly adhering to anything with which it comes in contact, while the sulphur acids, which it contains, corrode most substances. It would be hard to imagine a more objectionable kind of dirt.

A knowledge of the chemical composition and other properties makes the injury, which soot does to vegetation, evident to one acquainted with plant structure and growth. Soot is detrimental to the healthy development of plants, inasmuch as it (1) blocks the stomata of the plants and stops, to a greater or lesser degree, the transpiration; (2) covers the leaf with an adherent black coating, which cuts down the amount of sunlight reaching the chlorophyl and because of (3) the corrosive action of the tar, acids, etc. Evergreens, more especially the conifers, seem to be much more easily affected than other plants. On evergreen plants the leaves are exposed to the action of the soot for a much longer time than those which shed their leaves at least once a year. Therefore they become covered with a thicker coating of soot. The conifers also possess sunken stomata, which act as very effective pits to catch the soot.

One might think that the excess CO_2, which is likely to accompany the soot, would make plant growth more active, but it has been found that the increased percentage of CO_2 is not great enough to be a factor. Cohen compared laurel leaves from four different localities having different amounts of soot-fall and found the relative assimilations to be 100 — 52.8 — 45.2 — 11.6 respectively and roughly proportional to the soot-fall in these places. In England, ash trees have been observed to shed the leaves 4-6 weeks earlier in the smoky districts than in districts free from smoke.

Trees automatically keep record of their yearly growth by the width of the rings. A section of a Scotch fir, noted by Cohen, shows the date of the erection of a smoke producing factory near the tree, by the decrease in the width of the rings. Vegetables, such as radishes and lettuce, planted in different parts of Leeds, have been found to be stunted in their growth nearly proportional to the soot-fall.

The effect of smoke on buildings and building materials is marked and it soon destroys the appearance of buildings which cannot be cleaned. In smoky districts it is often necessary to modify a design in some respects because of the smoke. Skylights cannot be used advantageously, as they soon become coated with the black soot. Drain pipes must be arranged so as to avoid the splashing of water on the walls. Building materials (such as glazed tile), which admit of easy cleaning, are used much more in smoky cities than elsewhere. Granite and sandstone with a silicious binder form better building materials than limestone and sandstone with calcareous binder, which is easily corroded by acid in the soot and rain. Thus the stones which are most easily worked are undesirable in smoky cities. The sulphuric acid acts on the calcium carbonate, forming calcium sulphate, which is more readily soluble than the carbonate, also causing it to swell and become porous and friable as well as more disintegrated. Dr. Smith has found mortar to contain as high as 48.16 per cent $CaSO_4$, which was formed by the action of the sulphuric acid in the air, while limestone and marble have been found to contain from 0.52 to 3.85 per cent $CaSO_4$, due to the same cause.

FIG. 3.—PILLAR IN FRONT OF CARNEGIE LIBRARY, PITTSBURGH, SHOWING DECOLORIZATION BY SOOT.

The effect on most metals of the sulphuric acid, occluded in soot, is rather marked and greater than the action of a like amount of acid in the rain-water or air. It would seem, from observations taken in Pittsburgh, that the soot containing acid is made to adhere to the metals by means of its tar content, in which place it acts as the carbon; this, together with the metal and acid, forms an electrolytic couple, making corrosion much more rapid. In case of iron and aluminium the oxide is produced, at least in part, from the sulphate, and the acid is used over and over again.

To experimentally verify these observations, duplicate sets of various metals were fastened to two boards. One set was protected from the soot in the air by means of cheese cloth, yet still exposed to the air and rain. The other set was left unprotected. The pieces of metal left unprotected from the soot show a greater amount of corrosion than those which were protected.

I wish, here, to call attention to the following figures obtained by Messrs. W. B. Worthington and A. Rattray, showing how corrosion is accelerated by the acids in the air. Quoting from Cohen. "A number of rails were placed in suitable positions by the side of the line, and weighed at intervals and the loss in weight recorded."

The rails were of the ordinary railway section, weighing 86 pounds per yard. The annual loss of weight from corrosion was as follows:

	Loss in wt. in lb. per average year.	No. of years observation.
1. In the center of the town....	1.04	17
2. On the seacoast among sand hills	0.18	17
3. In a dry place in a smoky tunnel	1.48	13
4. In a wet place in same tunnel	1.71	8

The question of exterior and interior decoration is one affected as much by the amount of smoke in the air as by the tastes of the owners of the buildings. Interior draperies and paper are soiled much quicker in a smoky city than elsewhere. If light paper is used in papering the rooms, it must be cleaned every six months and new paper put on at least once a year to keep it looking only half as well as it would in a smoke-free city.

The effect of soot on paint is, in most cases, a matter of appearance only. The time, which it takes to spoil the paint depends, of course, on the amount of soot in the air, color of the paint, tar and acid in the soot. The number of paintings necessary in a given time depends on the above factors as well as upon the fastidiousness of the owner. In some cases the soot seems to act as a protective coating, while in others it has a corrosive action, destroying the surface gloss and rendering the surface more easily weathered.

Soot in the air of cities has a marked effect on the weather in a number of ways. By 1, cutting off the light; 2, by increasing the duration of fogs, and 3, by making the minimum temperature higher.[1]

As is well known, finely divided carbon in form of lamp black has the property of cutting off sunlight to a greater degree than most other substances. It is not surprising, then, to those of us who are acquainted with the soot clouds hanging over large cities, that the duration of sunshine has been found to be decreased 17 per cent, while if diffuse daylight is considered, the loss is even greater. Cohen finds, as an average of a large number of determinations made both in summer and winter, that fully 40 per cent of the light is cut off by the smoke-cloud and that the amount of light varies inversely as the amount of soot in the air. Dr. Russell states in his article, entitled "London Smoke and Fog," that the amount of soot in the airvaries greatly with the weather and gives the following figures to bear out his statement:

Fine weather .. .. 0.0035 gr. per 1000 cu. ft. air.
Dull weather .. .. 0.0103 gr. per 1000 cu. ft. air.
Foggy weather .. . 0.0244 gr. per 1000 cu. ft. air.

The amount of CO_2, H_2S, SO_2, together with the other gaseous products of combustion, also increase.

It may be said that each particle of moisture in a fog is formed or condenses around a solid nucleus or a dust particle. (This does not take account of ions, which are probably not of great importance in fog formation.) For this reason fogs might be thought to be of more frequent occurrence in the city than in the country. This is, however, not necessarily the case and as a matter of fact, dust particles are sufficiently numerous in the country as well as in the city for the formation of fogs. Smoke does, however, increase the blackness of a fog, making it much denser than the country fog, simply on account of the black soot particles. The fog is also apt to be of longer duration because of the oily tar in the soot, which forms a film over the outside of the drop, thus protecting it from evaporation. It is said that at least 20 per cent of the London fogs between September 1, 1902, and March 31, 1903, were artificially induced and preventable.

The amount of soot which falls on any area during a given amount of time, forms a subject of interest to the public at large as well as to the scientist. Cohen finds the air in dull weather to contain 0.0119 grams of solid matter, which he assumed to be soot, as it is always black, and these figures agree well with Russell's for dull weather. In Pittsburgh, I find that the amount of soot in the air corresponds remarkably well with the figures for the English cities.

Numerous measurements of soot-fall have been made in as many different ways by collecting rain and snow and by catching the soot in various forms of vessels.

1902 one snowfall	30 tons	Manchester . . .	100 sq. miles
	820 tons	Glasgow	per sq. mile
Snow	220 tons	Leeds	per sq. mile
Rain	259 tons	London	per sq. mile
Snow	600 tons	Indianapolis . . .	per sq. mile
Industrial center of Leeds		539 tons	per sq. mile
Suburban residence section of Leeds ...		26 tons	per sq. mile
Center of London		426 tons	per sq. mile
Sutton, Surrey, just outside the metropolitan area		58 tons	per sq. mile
Bo'ness, a small seaside village		72 tons	per sq. mile

Department of Industrial Research,
University of Pittsburgh.

[1] H. H. Kimball, unpublished paper.

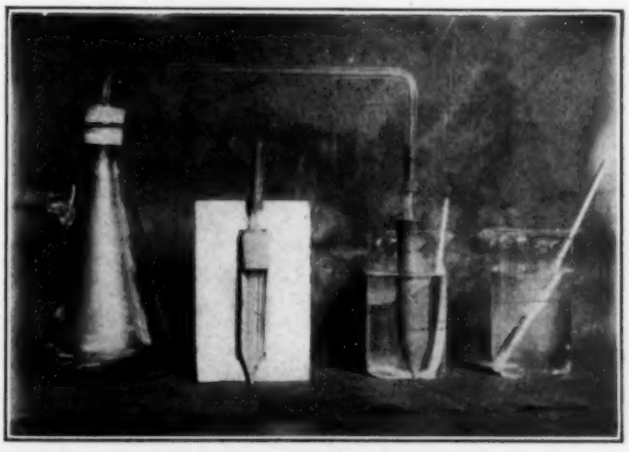
Application of the Alundum Extraction Thimble to the Determination of Copper.

BY L. W. BAHNEY.

The photograph shows the apparatus a little less than half size consisting of a filtering flask fitted with rubber stopper through which passes a bent glass tube, and an extraction thimble fitted with rubber stopper through which passes a glass tube of ¼-inch bore. Both tubes are connected by a short piece of rubber tubing.

A section of a thimble is shown in the photograph; the tube extends to within ⅛ in. of the tapered end.

The object of using the thimble is to remove the acid from the beaker after all the copper has been precipitated. This saves time, the copper is not exposed to the acid alone, and



ALUNDUM EXTRACTION THIMBLE.

there are none of the losses attending ordinary filtration. I have formerly accomplished this by means of a piece of perforated platinum fastened in the end of a ¼-in. bore glass tube with a filter mat of asbestos, but after my supply of proper length fiber became exhausted I could not get it after purchasing fourteen lots from four different dealers. This experience makes the thimble a piece of laboratory apparatus without contingencies.

The above apparatus may be used to remove at least ⅞ of a supernatant liquid from a settled precipitate without disturbing the latter.

The application of the thimble is best shown by partly outlining the assay for copper as follows:

Dilute the acid solution of copper and other sulphates to 150 cc in a 200 cc Jena beaker, place on a hot plate, add 2 drops of concentrated HCl then place a strip of aluminium in the beaker (this may be bent or straight as desired).

Connect the apparatus shown in the photograph with a filter pump having a strong suction.

When the copper is precipitated remove the beaker from the hot plate and insert the extraction thimble alongside the strip of aluminium. The acid solution will be drawn through the porous thimble.

Wash the upper end of the aluminium strip with a jet of hot water, wash down the sides of the beaker, add about 25 cc of hot water to cover the precipitate.

As soon as all the liquid is out of the beaker, disconnect the thimble by slipping the rubber tubing from the bent glass tube of the filtering flask, wash it with a jet of hot water. If there is no adhering copper, lift the aluminium from the beaker, add 5 cc strong nitric acid to the precipitated copper and carry out the titration in the usual manner. If the copper is in a finely divided condition as a precipitate on the aluminium, it will adhere as a black coating on the thimble, but as soon as the thimble is disconnected the water inside it will ooze out through the pores and if the 5 cc of strong nitric acid is poured over it the copper will immediately dissolve, and the thimble may be washed with a jet of hot water. The filtration is more rapid when the solution is hot.

If the last of the solution in the beaker is not withdrawn as rapidly as the first, tip the beaker at an angle of 45 deg. With a pump having a strong suction this is not necessary.

The thimble attached to the flask as shown above was used in over 300 determinations.

Sheffield Scientific School,
Yale University, New Haven, Conn.

Meeting of the (British) Iron and Steel Institute.

The fall meeting of the (British) Iron and Steel Institute was held in Leeds from Oct. 1 to 4.

The members were welcomed to Leeds by Lord Airedale and by the Deputy Lord Mayor of Leeds, the reply on behalf of the Institute being made by the president, Mr. Arthur Cooper.

The Bessemer medal for the current year was presented to Mr. J. H. Darby.

Soundness in Steel.

The first three papers presented at the meeting and discussed together had to do with different phases of the problem of the production of sound ingots.

Method of Producing Sound Ingots.

The first paper presented by Sir **Robert Hadfield** on his new "method of producing sound ingots" points out that the ingot maker is at present in a dilemma. If he makes his steel so that it will not settle, it is unsound. If he makes it sounder (using a small amount of aluminium), it pipes and so is still not satisfactory, and there is much waste. By using more aluminium he can make a steel that is quite sound, but the piping is almost as bad an evil as the unsoundness in the first case.

"The object in many steel works seems to be to try and avoid a steel which pipes or settles. This really arises from the natural desire to avoid the trouble and expense of making preparations for dealing with piping steel. The desideratum in the author's opinion is 'piping steel' which should be properly fed."

The author's new method of casting steel ingots, castings, etc., which insures soundness, freedom from piping, and absence of segregation, is illustrated in Figs. 1 and 2. It consists in heating the fluid steel in the upper part of the ingot or other mold and maintaining it in a liquid condition by the combustion, in contact therewith, or in close proximity thereto, during the cooling and shrinkage of the metal in the lower part of the mold, of solid fuel—for example, charcoal—by means of a blast of compressed air which is caused to impinge on the fuel while this is directly or indirectly supported by the metal below; and the interposition of a layer of fusible material, such as cupola slag, which has little or no injurious action on the metal, between the metal and the fuel. This slag largely prevents radiation of heat, the loss by which is much greater than ordinarily supposed to be the case.

In Fig. 2 the upper portion shows the charcoal. Then comes the layer of slag about ½ in. in thickness. Below it is the fluid steel in a 15-in. ingot-mold. The sand or other suitable top to provide the feeding head portion is inserted in the molding-box fixed on to the top of the ingot-mold itself. While the ingots can be cast as at present, that is, large end down, this particular design shows the small end of the ingot downwards. There is no doubt this is the better method, as by the small

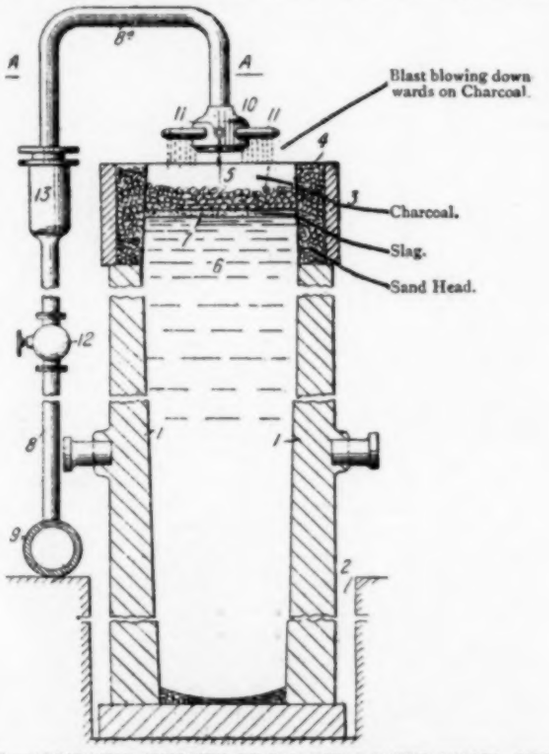


FIG. 1.—APPARATUS EMPLOYED IN PRODUCING SOUND INGOTS, SHOWING THE BLAST BLOWING DOWNWARDS ON THE CHARCOAL.

end forming the bottom portion, cooling takes place more quickly, causing the steel to congeal there and thus reduce the amount of feeding required later on from the upper portion of the mold.

"The cost of carrying out the method is trifling compared with the large saving effected by reducing loss and waste of material. Moreover, the quality of the product is improved; for example, in making rails produced from such ingots, not only is there less discard, but the material is sounder. During the last few years many thousand tons of ingots have been made by this patented process, which has been found of great advantage.

"As a specific example, it may be mentioned that ingots have been made, weighing about 5000 lb. each, in which the piping and discard do not amount to more than about 7 per cent. This small loss is not the only advantage, the chief one being that material is obtained which is quite sound and free from hidden pipes or other defects on the whole length of the ingot. The system can be applied equally well to either smaller or larger ingots, for all kinds of purposes, and for ordinary or special steels.

"It is estimated that on a large output the saving by this method is from about 8 s. to 12 s. ($2 to $3) per ton. Thus, on a large tonnage of hundreds of thousands of tons annually there would be a very considerable saving each year, as well as obtaining sound ingots free from blowholes, piping, and segregation.

"In this experiment even the segregation usually noticed was almost entirely absent, only a few inches below the feeding

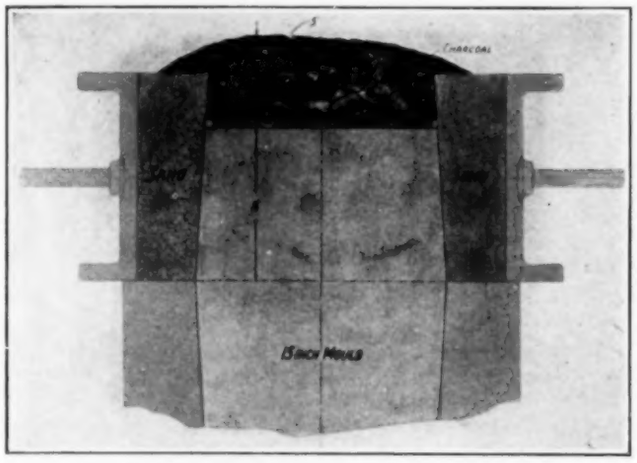


FIG. 2.—METHOD OF MAKING THE INGOTS.

head placed on the top of the ingot. At about 4 in. below the surface of the sinking head the percentages of sulphur and phosphorus were practically the same as in the original steel, namely, about 0.03 per cent each."

The paper gives a great many details of the results obtained with the process in commercial practice.

Revealing Segregation in Steel Ingots.

A second paper by Sir **Robert Hadfield** dealt with "a new method of revealing segregation in steel ingots."

At a certain stage of the cooling-down process of molten steel the complex phenomenon of liquidation is met with and causes much difficulty. While sulphur and phosphorus give the most trouble, these remarks also apply to the element carbon and the metal manganese alloyed with iron, and to a less extent as regards nickel and chromium. This segregation of the elements referred to gives a brittle, impure, and weak steel, which in the finished article may prove not merely objectionable but dangerous. There is no proof that segregation occurs in fluid steel itself, that is, all the elements are then well fused and not segregated; the difficulty begins as soon as the mass commences to cool down; in other words, segregation appears to be a function of the lowering of the temperature. The difficulty only arises in cooling down, and in that portion of the ingot or casting where the ferro-static pressure is lowest.

The author's research as to a method for revealing the way how segregation arises "commenced in this manner. It was reasoned that possibly some addition, preferably metallic, could be made to steel while in its molten or partly fluid condition which would give the desired effect. Thus upon breaking up the ingot when cold, if it would show the presence of the added metal in some clear and definite manner, such as by difference in color, useful information would be obtained. The author, therefore, after a considerable number of experiments with various metals, selected copper, which, by its slightly higher specific gravity as compared with iron, would have a tendency to fall or drop down the central portion of the ingot being experimented upon; moreover, by its distinctive color at the parts where it is alloyed with the iron its presence would be apparent."

The results of various experiments made by the author with this method are described and shown in elaborate diagrams. The first experiment described was made with a small ingot of steel (with an ingot mold of cast iron and an ingot head of sand to keep the metal in the lead fluid for a longer time); soon after the ingot was cast a little molten copper was poured into the head. It was found that it penetrated into those portions of the ingot where piping usually takes place, and thus indicated the exact location where what may be termed intercrystalline unsoundness or segregation is developed. It may be mentioned that this particular type of inter-crystalline unsoundness is not usually seen or detected in the fracture of an ordinary ingot when cold; it is only revealed by a polished section after etching. The cuprous areas in these small ingots probably represent these segregation areas.

One of the general results clearly shown by the author's experiments is that "the interior of an ingot, even of small size —and it will be, therefore, more so in a large ingot—remains hotter for a much longer period than has been thought to be the case. It can, therefore, be more readily understood why segregation proves so harmful, for, owing to this longer time of cooling and the reduction in the ferro-static pressure, naturally much greater opportunity occurs for the liquation of such harmful elements, sulphur and phosphorus. The more quickly the steel sets, the less opportunity is therefore given for this segregation. The fact has long been known in a practical way, but the reason for it has not been so apparent. The results of the present experiments seem to clearly indicate why quick cooling is advantageous."

Improving Soundness of Steel by Thermit.

A paper by Dr. **Hans Goldschmidt,** of Essen-Ruhr, Germany, describes "a new method for the improvement of the soundness of steel ingots by the aid of thermit." Dr. Goldschmidt explains the loss of homogeneity of molten steel in the course of solidifying as follows:

Steel, made by a fusion process, must be regarded as an alloy of iron with several elements, more particularly carbon, manganese and silicon; phosphorus, sulphur and copper being also present as impurities. The purer the iron the higher its melting point. The other constituents of the alloy, especially carbon, and also phosphorus and sulphur, have the effect of lowering the melting point. In the production of steel, therefore, the purest constituents, that is, those which have the highest melting point, are the first to solidify and settle at the bottom and sides of the ingot mold. At the center and head of the ingot, on the other hand, where the metal remains longest fluid, are gathered the more readily fusible impure elements which have separated out during cooling. The principal elements which accumulate near the top in this way are sulphur and phosphorus, etc., which exercise so injurious an influence on the mechanical properties of the material.

The serviceableness of an ingot is not only reduced by the process of segregation, but by a whole series of other defects arising during cooling and freezing.

For instance, during the transition from the liquid to the solid condition the volume of the ingot undergoes a change due to shrinkage. As solidification progresses from the sides and bottom inwards and upwards, the neighboring layer of liquid and semi-liquid material are attracted owing to the gradual diminution of the volume until finally, in the center of the ingot and towards the end, a large hollow space, known as the pipe, is formed, which is the distinctive and objectionable defect of almost all steel ingots. There is further the evolution of gases and the formation of blowholes.

The question of the prevention of piping in ingots is one that has always occupied the attention of metallurgists, and, among other remedies, the use of thermit was long ago recommended. The method of its application was to break open the crust which formed at the top of the metal in the mold and to plunge a cartridge filled with thermit into the pipe in order to remelt the surrounding parts. As soon as this remelting was effected, the hole was filled by pouring in fresh liquid steel from the ladle. The process as thus carried out was, therefore, a purely thermal one.

Unfortunately the method did not yield the desired results in spite of the numerous trials made at a great many steel works. In fact, it was only in exceptional cases that success was obtained, so that it was no wonder that this so-called anti-piping thermit process was soon discredited and forgotten.

Latterly, however, a new and very successful improvement of that old process has been made, which has proved very efficacious, especially in the treatment of non-siliconized steel, that is, steel to which no silicon addition has been made either in the furnace or in the ladle. At first sight it might be thought that the method had been altered only in one small detail, for the apparatus, consisting of a sheet metal cartridge filled with thermit, has been retained. It differs totally, however, in the mode of application and the result achieved.

Whereas formerly the thermit cartridge was used solely for the purpose of melting the upper portion of the ingot containing the pipe, the lower end having already solidified, the cartridge, according to the new method, is quickly plunged right to the bottom of the ingot before solidification has begun to set in, that is, before any of the defects referred to have had time to take effect. The reaction immediately causes an energetic ebullition of the liquid contents of the ingot mold. The most noticeable feature is the sinking down of the liquid metal in the mold by more than a hand's breadth as soon as the reaction is complete, and the density of the material is increased by an amount corresponding to this reduction of volume. Further metal is then poured in from the ladle until the level of the ingot is restored, and the ingot, if of non-siliconized steel, is then covered with an iron plate in the usual way.

The violent frothing up, due to the reaction of thermit, has other good effects, for the segregation already accumulating in the center is driven upwards and further segregation is prevented.

The new method has proved particularly effective for the treatment of ingots intended for **rolling into plates**, and the advantages here are very apparent. In this connection the new process was first tried at a steel works combined with a plate rolling mill, namely, the German firm of Schulz-Knaudt, A. G., and it was due to the enterprise of the steel works manager, Dr. Canaris, assisted by Mr. Biewent, engineer of Messrs. Th. Goldschmidt, A. G., of Essen, that the process was first put into practical operation.

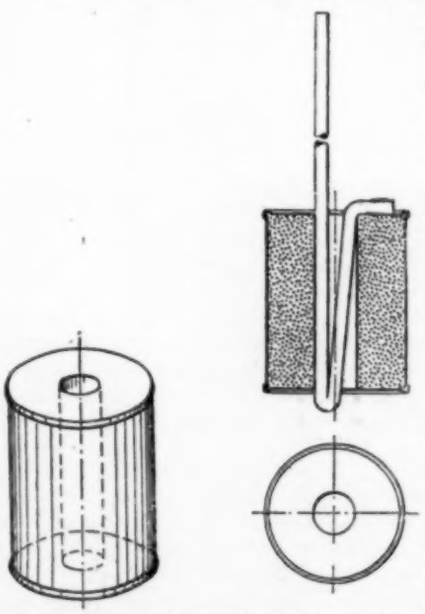
Referring now to the results obtained with plates rolled from slabs treated with thermit in this manner during the trial of the thermit process at those steel works more than 4000 ingots, varying from 1 to 8 tons in weight, were treated as described, and exact records were kept of the working results. (From Nov. 1, 1911, till July 31 of this year 17,891 ingots were treated in the same steel works. The ingots varied from 1 to 11 tons and emanated from 1436 different heats.) It was found that the number of plates rejected, owing to the faultiness of the ingot, amounted only to 0.3 per cent of the total weight of the ingots, whereas in many works the percentage of rejection amounts, as is well known, to 15 per cent or more. That figure of 0.3 per cent could have been still further reduced if the defects due to rolling alone had been also taken into account.

In view of the fact that the quality of the ingots was improved in every respect, and that a much greater regularity in working was ensured, it was soon found possible, keeping the plates the same weight as before, to reduce the weight of all the ingots by 5 per cent, that is, to make them 5 per cent less weight than is required in general practice. The principal advantage is that due to economy in rejections, but whereas this saving cannot very easily be calculated in exact figures, the advantage due to the 5 per cent reduction in the weight of the ingot can be accurately computed. Assuming that the rough finished plates are worth £6 a ton and that scrap costs £3 a ton, the difference in value of the raw material and the finished product is £3 per ton, or 60 s., that is to say, the 5 per cent reduction in weight represents a saving of $5 \times 60 \div 100 = 3$s. Since the cost of the thermit process, under the least favorable conditions, that is, if only small ingots are cast, does not exceed 1 s. 6 d. per ton a net saving of at least 1 s. 6 d. per ton of plates rolled results. In the case of large ingots the economy is considerably greater for the reason that the cost of the thermit treatment is then reduced to one-half or even less. The proportion of wages and consumption of red iron is the same for a large as for a small ingot, while the quantity of thermit used is relatively smaller per unit of metal.

Further advantages are that the quality of the plates produced is much improved, and, in particular, the strength in different parts of the plate is much more uniform, this being due to the prevention of segregation. Added to this there is also the capability of increasing the output without injuring the plant, and the quantity of waste is much reduced. The working of the rolling mill proceeds with greater regularity owing to the reduction of the number of wasters to a minimum. Therefore, no interruptions need occur in the execution of orders. Dr. Canaris pronounces the process to be an ideal means for the improvement of the quality of the ingots.

Tables are given in the paper showing analyses and tensile tests of thermit-treated plates, further comparisons of the mechanical properties of thermit-treated plates with untreated plates.

Another important advantage of the process is that for carrying it out no special apparatus is necessary, and no cost is incurred for the instalment of such apparatus. All that is required is the sheet-iron box with thermit of the proper capacity and an iron rod, by the aid of which the box is thrust down into the molten metal.



FIGS. 3 AND 4.—SHOWING THERMIT CARTRIDGE AND ROD FOR PUSHING TO THE BOTTOM OF THE INGOT.

The exact method of carrying out the process on ingots of non-siliconized material is as follows: the filling of the ingot mold is effected in the usual way, either by direct pouring into each mold from above or filling a number of molds simultaneously by bottom - pouring. After filling, the molds are left undisturbed until the crust, which starts from the sides of the mold, has spread some little way inwards. This crust gives an indication of the progress of cooling, and hence of the right moment at which to introduce the thermit cartridges. The width which the crust should be allowed to attain depends, of course, upon the size of the ingot, and is a matter that can only be judged by experience.

The thermit cartridge (Fig. 3) is preheated, and by means of the rod shown in Fig. 4 is thrust vertically down to the bottom of the ingot mold and is held there till the reaction is complete, the rod being then withdrawn. A scrap-iron rod will serve the purpose and should be about ½ in. in diameter, or somewhat stouter for the larger boxes. To economize material the bar can be made so that either end can be used.

If the operation is performed at the right moment the surface of the ingot sinks down at once by several inches or more directly the boiling ceases. More metal is then poured in at

the top until the surface is again restored to the original level, where the crust first began to form, and an iron plate is then lightly placed on the metal in the usual way and then covered up with sand.

The process is actually nothing less than a stirring up process, that is to say, a purely mechanical and not a thermal one. Since the weight of thermit required for a 1-ton ingot is only a little over 1 lb., the rise of temperature is practically nil.

The certainty of being able to produce sound ingots with a very small proportion of discard makes it probable that in future ingots of large size only will be cast, from which small-size plates will be rolled. The waste due to trimming and cutting up will be inconsiderable. Up till now it has been inadvisable to make large ingots on account of the large percentage of discard and the resulting disproportionate waste of material. The increase of density and the improvement in quality of the steel are also to be reckoned as economies, and it is by no means unlikely that the thermit process may lead to modifications in rolling-mill practice generally.

* * *

Improvements in Yield.

A Modification of the Pig Iron, Scrap, and Ore Process.

Mr. **F. W. Paul,** of Glasgow, presented a paper on the "manufacture of open-hearth steel with reference to improvement in yield." The author discussed the reasons why in the development of the open-hearth steel process the hope for an increase of yield with an increase of furnace capacity and weight of charges had not been realized. He also gave some details of a new way of conducting the pig iron, scrap, and ore process which in a few trials in practice in 80-ton furnaces had resulted in an increase of yield by 5 to 7 per cent.

One of the direct causes of actual decrease of yield with increase of furnace capacity is, in the author's opinion, the reduced ratio of bath area to weight of charge. While in 1880 for a 10-ton charge the bath area was 140 sq. ft., it is in the present year for an 80-ton charge only 490 sq. ft., so that the area ratio has been reduced from 14 to 6.1 sq. ft. per ton.

The author's proposed new method of charging and silicon elimination in the pig iron, scrap, and ore process is as follows:

Charging.—Instead of the pig iron being charged in one continuous operation, only a small fraction is taken, about 5 to 10 per cent, and brought to a molten state, and thereafter the subsequent additions of pig iron are charged into this initial bath of molten metal, which is maintained in liquid form substantially during the entire period of charging.

After the pig iron is all charged, and the silicon sufficiently removed to permit of superheating the metal without loss, or after the metal has been brought to the boil, the steel scrap is charged in such increments and at such rate as is commensurate with the heating capabilities of the furnace maintaining the bath in liquid form.

As regards the use of molten pig iron in basic or acid furnaces, this method of dealing with fractions of the charge *pari passu*, with additions of iron oxide, permits of the elimination of silicon at low temperature and so avoids the fluxing of the banks and thus affords, in the basic especially, means of working with low-sulphur pig iron and greater latitude as regards contents of silicon.

Melting.—The heat of the flame is in direct contact with each successive addition of pig iron and scrap floating on the surface, consequently the gas and air can be maintained at their maximum and the temperature of the furnace and metal regulated by the rate at which cold material is fed into the furnace.

The pig iron and scrap floating in a molten bath of metal with a protective coating of slag are protected from the oxidizing atmosphere of the furnace. Less waste ensues and the yield is increased.

Elimination of Silicon.—Another important feature of this method is the practical means of arranging the most suitable conditions for removal of silicon and obtaining its equivalent reduction of iron from iron ore without diminishing the number of charges per week.

During the additions of pig iron as described above under "Charging," oxide of iron is added in sufficient quantity to eliminate the silicon. By this means the melting stage and the silicon elimination stage are merged into one. The elimination of silicon is carried on concurrently with melting. That is, for a period of six hours or more with the metal at low temperature, so that the scouring action on the banks is considerably diminished. The silicon should be eliminated previous to charging the steel scrap.

An Analysis of Steel-Works Yields from Practice.

A paper on "steel-works yields" by Messrs. **Percy Longmuir** and **W. H. Robinson,** of Sheffield, was then presented by the former.

Studies of production have as an ultimate object increased efficiency. In some cases efficiency is judged by quantities, in others by quality of product. Irrespective of the point of view, before any alterations in method are tried, cut-and-dried data as to existing practice should be obtained. With this end in view a very close study has been made by the authors of the conditions of production in a steel works engaged on products of high quality and wide variety.

Metallic Yield.—The yield of a process is here taken as including all metallic products. Scrap—that is, runners and defectives—are differentiated later. The yield figure obtained is calculated from the metallic portion of the charge; thus, in the case of the open-hearth steel, ore and scale are not counted as portions of the metallic charge. The data from this source are given in a table of the Appendix of the paper, which is not reproduced here, and the figures there shown when averaged give the following values:—

Weekly Yield and Loss Per Cent. as Averaged from the Year's Working.

Type of Steel.	Yield. Per Cent.	Loss. Per Cent.
Bessemer	88.81	11.19
Open-hearth basic	95.35	4.65
Open-hearth acid	96.24	3.76
Crucible	98.81	1.19

Higher yields than these have been published. However, it should be noted that the authors' records do not represent selected runs, but the whole of a year's working, and they, therefore, give all varieties of condition as regards plant and its operation.

An analysis of the metallic product includes defective steel and scrap produced in the steel-making operations. The year's working in this respect is summarized in another table, not reproduced here.

This table when averaged as in the previous case, gives the following weekly values:

Weekly Defective and Scrap Per Cent. as Averaged from the Year's Working.

Type of Steel.	Defective. Per Cent.	Scrap. Per Cent.
Bessemer	0.26	4.06
Open-hearth basic	0.24	1.65
Open-hearth acid	0.14	2.37
Crucible	0.52	14.93

Defective and scrap are self-evident terms. Certain fluctuations are shown in the weekly returns, and it should be noted that the volume of scrap is very largely determined by the type of ingot and the method of casting, conditions subject to variation according to the type of work in hand. All crucible ingots are topped down to approximately one inch below the bottom of the pipe before passing forward to the mills. The low percentage of scrap in this case is due to the use of white-hot clay feeding heads.

After actual steel-making, the first selective process is that of reduction from ingot into billet, bloom, or rail, and it is here that the effects of cropping off piped portions, short lengths,

etc., are felt. The weekly results are given in another table, not reproduced here. The range of steels varied from 0.10 per cent to 1.45 per cent with a general average of about, 0.80 per cent. carbon. The data included in that table when averaged is shown to yield:—

Rail and Billet Mill Results. Weekly Average, Year Ending December, 1911.

Type of Steel.	Good. Per Cent.	Defective Rolling. Per Cent.	Scrap. Per Cent.	Loss. Per Cent.
Bessemer	78.63	0.16	18.01	3.20
Open-hearth basic	79.63	0.03	17.28	3.06
Open-hearth acid	77.20	0.08	19.84	2.88

The bar mill values are given in another table, and these give a weekly average as follows:—

Bar Mill Results.

Type of Steel.	Good. Per Cent.	Defective Rolling. Per Cent.	Scrap. Per Cent.	Loss. Per Cent.
Bessemer	94.28	....	1.97	3.75
Open-hearth basic	95.05	0.01	0.89	4.05
Open-hearth acid	93.55	0.01	2.62	3.82
Crucible	93.68	0.08	2.71	3.53

The bar mill product is of a very varied character, and includes a large proportion of hot rolled strip steel. The greater stringency of conditions in a rod mill is exemplified in another table. The substance of this table is as follows:—

Rod Mill Results.

Type of Steel.	Good. Per Cent.	Defective Rolling. Per Cent.	Scrap. Per Cent.	Loss. Per Cent.
Bessemer	90.25	2.21	3.38	4.16
Open-hearth basic	89.98	2.95	2.84	4.23
Open-hearth acid	90.68	2.74	2.66	3.92
Crucible	92.53	0.79	2.96	3.72

Turning to an entirely different type of product, namely, tires and axles, the conditions differ as regards scrap in that greater allowances have to be made. A hole has to be punched through the tire block, and a certain latitude has to be allowed in the case of forging axle blooms. Tire results are given in a further table, and when summarized yield the following weekly averages:—

Tire Results.

Type of Steel.	Good. Per Cent.	Defective Rolling. Per Cent.	Scrap. Per Cent.	Loss. Per Cent.
Bessemer	81.71	0.01	14.82	3.46
Open-hearth acid	84.42	0.18	11.94	3.46

For the axle values the weekly average is as follows:—

Axle-forging Results.

Type of Steel.	Good. Per Cent.	Defective Forging. Per Cent.	Scrap. Per Cent.	Loss. Per Cent.
Bessemer	86.23	....	10.14	3.63
Open-hearth acid	85.78	0.19	10.68	3.35

"The labor of collecting the data here presented has not been light, and the authors have to thank Mr. H. Greenwood for his accurate work in this direction. The authors' thanks are due to Mr. F. Scott Smith, general manager of Messrs. S. Fox & Co., Ltd., Sheffield, for his sympathetic encouragement and for his ready permission to publish the data obtained.

"Finally, the collection of data of this kind forms a very considerable help to the management in the way of production and costing. Before any changes are made, it is most essential that the real work of existing plant be known. Real work can only be found by long observation, and in this direction selected runs or selected periods are useless and misleading."

The last two papers were discussed together.

An account of the discussions as well as of the further proceedings of the meeting will be given in the monthly letter of our London correspondence in our next issue.

Some further abstracts of papers presented at the meeting are here added, prepared from advance copies, which were sent to us by the Secretary of the Institute.

Iron and Nitrogen.

A paper by **J. H. Andrew** of the University Manchester gives an account of experiments on the effect of nitrogen gas on the critical ranges of the iron-carbon alloys. The method of investigation consisted in melting the metal under a moderately high pressure of nitrogen gas and then cooling the product as quickly as possible in order to retain the maximum amount of gas. For these experiments a high-pressure electric furnace was used. The chief conclusions of the author are as follows:

Iron and iron-carbon alloys absorb small amounts of nitrogen when melted under a high pressure of the gas.

The absorption of 0.3 per cent of nitrogen entirely suppresses the critical changes occurring in pure iron, and prolonged heating in vacuo is required in order to denitrogenize the metal.

The absorption of 0.25 per cent of nitrogen by a 0.6 per cent carbon steel lowers the Ar1 point to a marked degree. Such a nitrogenized steel can only be brought back to the normal state of a pure steel by several weeks' heating in vacuo.

The author considers that the critical changes occurring in iron and steel are due to the coalescence of like molecules, and that this coalescence is due to the contraction of the metal during cooling, bringing the molecules sufficiently near together for the force due to the molecular attraction of like molecules to exert itself, and overcome the influence of the intervening molecules.

The absorption of nitrogen, followed by the formation of iron nitride, prevents the iron molecules and the iron carbide molecules from coalescing with molecules of their kind by keeping them apart. This will necessitate greater contraction of the metal, and therefore a lower temperature, before the like molecules are brought sufficiently near together for the force due to molecular attraction to effect a change.

The effect of nitrogen upon the mechanical properties is made evident by consideration of its influence upon the critical change.

Hydrogen has no influence upon the critical changes when introduced into the liquid metal under pressure.

The Magnetic Properties of Manganese and Nickel Steels.

A paper by Dr. **S. Hilpert,** of Charlottenburg, Germany, and Dr. **W. Mathesius,** of Worcester, Mass., gives the results of an investigation in which the magnetic properties (intensity of magnetization and coercive force) of previously heat-treated steels were measured at ordinary temperatures. Three of the steels investigated contained from 12 to 27 per cent of nickel, 0.5 manganese and 0.12 to 0.21 per cent of carbon. Four of the steels contained no nickel, from 4.6 to 20.8 per cent manganese and from 0.27 to 2.18 per cent carbon. Diagrams are plotted for the majority of the steels, which give a clear indication of the dependence of the magnetic properties upon the previous heat treatment.

In all the steels the magnetizability after quenching from 1200° C. was greatly increased as compared with that of the same material after similar treatment at lower temperatures and also after slow cooling. By means of systematic thermal treatment in combination with magnetic measurements, it is shown that at high temperatures (above 1050° C.) substances are formed which at ordinary temperatures are strongly magnetic, but in spite of quenching cannot be obtained in a pure state. The assumption that gamma-iron must always be non-magnetic cannot be maintained. In general the dependence of the magnetic properties upon the previous heat treatment is too complex to permit of explanation by the usual theory of allotropy.

All the steels, with the exception of the nickel steel with 31 per cent of nickel, showed both in the quenched and in the slowly-cooled specimens an increase in the magnetizability when annealed at temperatures between 400° and 450° C. This is not, in any case, an aging phenomenon, but is the result of a

new state which is obtained only by a heating process. In general, the fact whether the heat treatment has been carried out under a rising or a falling temperature has a decisive influence upon the magnetic properties.

The metallographic investigation in relation to the magnetic properties showed that there was no distinctive structure which was characteristic for magnetic and non-magnetic steels.

Gases Evolved from Steel.

A paper by **G. Wesley Austin** gives the results of experiments carried out in the University of Birmingham "on the gases evolved on heating steel to its melting point in a vacuum." The samples of the steel under tests were used in form of rods between copper terminals and melted electrically by strong currents (1,000 to 20,000 emperes). The rod was contained in an air-tight furnace in form of a weldless steel tube from which the air and gases were pumped out.

In conducting an experiment the heating was carried out in three stages, each of half an hour's duration. The current was first adjusted to raise the bar to a temperature not exceeding 900° C. The temperature was next increased to about 1100° C., and finally, in the third stage, the bar was fused. The gases evolved during the several stages were separately collected.

Samples of the following five materials were treated: Cast iron of soft grey quality, cupola melted; Sheffield crucible steel; medium open-hearth steel; mild open-hearth steel; mild Bessemer steel.

In the case of cast iron and crucible steel the different extracts of gases did not materially differ in composition; for example, a cast iron specimen at a red heat evolved gases containing 24.0 per cent carbon monoxide, while immediately prior to fusion the gases contained 22.5 per cent, the difference being relatively slight. The percentage of carbon monoxide was rather lower in the gas obtained at lower temperatures, than at higher heats from medium carbon steel. Thus one specimen yielded a first extract containing 34.7 per cent carbon monoxide and the last 42.7 per cent.

The first extracts from the mild open-hearth steel were undoubtedly richer in hydrogen, one specimen evolving at first a gas of the composition:

	Per Cent
Carbon dioxide	7.7
Carbon monoxide	18.4
Hydrogen	59.1
Nitrogen	14.8

whereas the gases evolved from two specimens during the last stage in the heating yielded

	I	II
	Per Cent	Per Cent
Carbon dioxide	1.4	1.5
Carbon monoxide	65.7	59.0
Hydrogen, nitrogen, etc.	32.9	39.5

In consideration of the somewhat uneven heating and melting of the bar, definite conclusions cannot be drawn regarding the precise amount or composition of the gas evolved during a certain temperature interval. It will be observed however, that:—

1. The volume of gas evolved from cast iron is relatively much smaller than from steel; moreover, the percentage of carbon monoxide is considerably lower.

2. The higher the carbon content of the steel the larger the amount of evolved gas.

Problems of Wire Drawing.

A paper by **Percy Longmuir**, of Sheffield, discusses some "aspects of wire drawing."

The physical condition of the rod is discussed at some length. If cold-working is to be effective, the rod must be uniform throughout its length. With the long lengths of today perfect uniformity in the rod "as rolled" is impossible, and of necessity the finishing temperature of the back end differs materially from that of the front end. There is, therefore, a corresponding difference in the condition of the rod, and, generally speaking, it will be found gradually to increase in hardness from the beginning to the end of the coil. This difference between the ends may be comparatively light, but unless the rod is initially equalized throughout its effect will be felt in the later stages of drawing.

Results of tests are given in which special efforts were made to insure uniform conditions in rolling. The length of the rod was 1154 feet. The maximum stress in this case was at the beginning of the coil 47 tons per square inch and at the end of the coil 50 tons per square inch.

The difference between the back and front end is in this favorable case only 3 tons per square inch on the maximum stress. Slight as this difference may appear to be, it would, in the absence of a normalizing process, have a very material effect on the "flow" of the wire during drawing.

"Industrial 'flow' demands equality of section, therefore the reduction in area effected by drawing through a plate must be uniformly consistent throughout the length of the wire. The general tendency is to put cold work on a hot rolled rod before any normalizing has been effected, and in these cases the effect of cold working is such as to develop a habit which persists through later annealing stages. This habit may take the form of 'non-sizing'—that is, pulling out the hole, or acute local brittleness. In either case the wire-drawer usually blames the steel, and so far as the Yorkshire wire-drawing districts are concerned, the usual phrase is: 'The composition has been altered.'

"Many cases have been investigated, and in not one instance has composition been found to be at fault. In all cases the steel, considered as steel only, has been found to be correct, but its manipulation has been wrong. One of the first studies in manipulation is that of obtaining physical uniformity throughout the length of the wire, and it is here that the least work has been done.

"If the rod as hot rolled is not in a state of equilibrium, then cold work intensifies, and to some extent fixes, its condition, and later heat treatment does not necessarily remove a 'fixed habit.' The first care of the wire-drawer should, therefore, be that of effective normalization, and this may be obtained by patenting or annealing. In either case the process must have some relation to the thermal transformations of the steel in question.

"A study of current wire-drawing practice reveals the fact that generally annealing operations have no relation to thermal transformations. Temperatures are rarely taken, and the only guide is empirical judgment. Over a variety of practice the range in temperature may be estimated to vary from 550° to 700° C. Both temperature and time decrease with the reduction of the wire in size. This would indicate that wire-drawers have to some extent intuitively recognized that only the effect of the cold working has to be removed, and therefore, Goerens' 'low'-temperature annealing has long been recognized in practice.

"The effectiveness of this annealing is open to question, and not only is the 'flow' less the lower the temperature, but further, the resulting hardness is greater. Advantage can be taken of this fact when working to a definite hardness value in either cold rolled strip or drawn wire. By suitable adjustment of annealing temperatures to cold work a given hardness can be obtained, to a certain extent, irrespective of the composition of the steel. This emphasizes the fact that if annealing temperatures are to be seriously studied, then a sharp line must be drawn between the first and the latter annealings. The first annealing should relate solely to the condition of the hot-rolled rod, while later annealings have a relation to the stresses developed by cold working."

In the concluding part of the paper the author gives extensive tables showing the tensile values obtained from successive

stages of cold work without any special heat treatment after the initial one before the cold work begins. One of the tables illustrates very well the fact that cold work can be so adjusted as to give, within limits, hardness irrespective of composition.

* * *

Other papers presented at the meeting were the following on new type:

A New Type and Method of Construction of Large Gas Engines (vertical duplex type), by **Alan E. L. Chorlton,** of Manchester.

Does Commercial Hyper-Eutectic White Iron Free from Manganese Exist? by **Prof. Henry M. Howe,** of Columbia University, New York City.

The Iron Ore Resources of Chili, with a note on the Corral Iron and Steel Works, with its wood-fired blast furnaces, by **Charles Vattier,** delegate of the Chilian Government.

The Growth of Cast Irons after Repeated Heatings (Parts V and VI) by **Prof. H. F. Rugan,** of Tulane University of Louisiana, New Orleans, La.

The Solubility or Diffusion of Hardenite in Ferrite, by **Prof. J. O. Arnold** and **C. Chapell,** of the University of Sheffield.

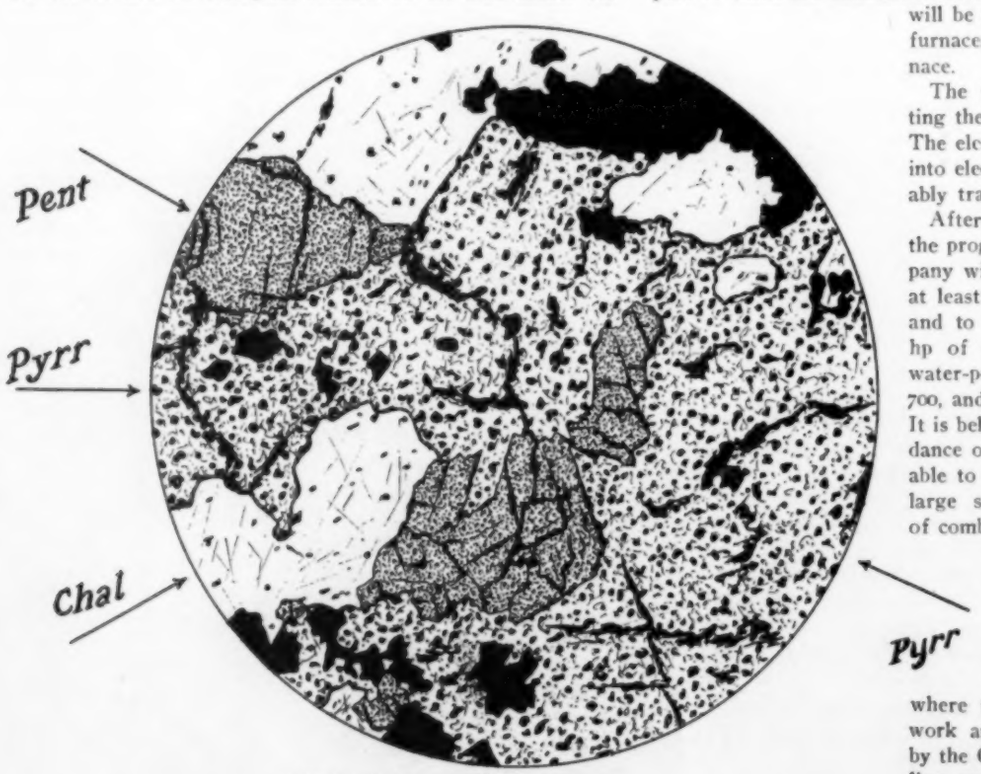
The Soiubility of Cementite in Hardentite, by **Prof. J. O. Arnold** and **Leslie Atchison,** of the University of Sheffield.

On Allotropy in General and that of Iron in particular, by **Prof. Carl Benedicks,** of the University of Stockholm. The results of this paper were already given in connection with a paper by the same author, presented before the International Congress of Applied Chemistry, and abstracted in our October issue, page 602.

Occurrence of Pentlandite in the Sudbury Ores.

By F. W. Apgar and Kirby Thomas.

The micrograph herewith reproduced shows very well the occurrence and mineralogical relation of the iron nickel sulphide, pentlandite, (FeNi) S, in the typical nickel-copper bearing ores of the Sudbury, Ontario, district.



MICROPHOTOGRAPH—62 DIAMETERS.

The specimen used for this sketch was from near the footwall of the Mount Nickel Mine and shows rather more than the usual proportion of chalcopyrite. The black spots are remnants of the nickel-bearing eruptive, a norite of charactertistic type associated with the ore bodies and from which primarily they were derived by processes of magmatic segregation with probable later concentration through redeposition.

The pyrrhotite is magnetic, though feebly, and this suggests the possibility of magnetic beneficiation of the ore, but so far no commercial application of the idea has been made.

The Iron Ore Mines of Cogne (Valle d'Aosta) and the Projected Electric Pig Iron Plant.

The famous Valle d'Aosta, known by its ancient history as well as by the romantic beauty of its scenery, will give rise to a modern development of metallurgical industry. A recent issue of the "Rassegna Mineraria Metallurgica e Chimica" gives a description of the program which the "Societa miniere di Cogne" intends to carry out. There are iron ore deposits in about 16 1-4 miles distance from Aosta on the banks of a small tributary of the Dora. They are found in a height of between 6500 and 8200 ft. above sea level, which would mean about 4500 to 6000 ft. above Aosta.

The available supply of ore has been calculated as being 6,000,000 tons of the first quality, containing 60 per cent of iron, practically free from sulphur and phosphorus, and the conditions under which the new company will start operations are very promising. The following is their program: An aerial railway will carry the mineral down to Cogne with a drop of 1500 to 3000 ft. over a distance of about 2 miles. In the latter place the ore will be crushed, concentrated and brought into a pasty condition. By adding sufficient water this mixture will flow, with a drop of 5 per cent, through tubes to a place of 14 miles distance. At this place, called Aymaville, the ore concentrates will be pressed into briquettes containing 70 per cent of metal, part of which are intended to be sold in open market. The rest will be charged into electric pig iron furnaces and one ordinary blast furnace.

The process applied for briquetting the ore is the one of Groendall. The electric pig iron will be charged into electric steel furnaces and probably transformed into tool steel.

After a complete development of the program laid out so far the company will be in condition to produce at least 180,000 tons of ore per year and to obtain on an average 37,000 hp of electrical energy from four water-power stations of 19,500, 8000, 700, and 900 hp capacity respectively. It is believed that with such an abundance of power the company will be able to utilize electric furnaces on a large scale, operated independently of combustible fuels, and in this way to establish an entirely national Italian industry.

The Sherardizing process is making rapid progress in this country where there are some 34 plants at work and is being extensively used by the General Electric Company for line material. A committee of the Franklin Institute of the State of Pennsylvania have recently made a report on the process and have awarded the inventor, Mr. Cowper-Coles, of London, the John Scott Legacy Medal and Premium.

American Electrochemical Society Papers at the International Congress.

Since the American Electrochemical Society decided not to hold a special fall meeting this year in view of the Congress of Applied Chemistry, those papers which were available were presented at joint sessions of the Congress and of the Society.

In the following we give abstracts of three American Electrochemical Society papers which have not yet been reported in these columns.

Fixation of Nitrogen by Alumina and Carbon.

A paper by **Professors S. A. Tucker** and **Henry L. Read,** of Columbia University, gives the result of an investigation made to find out whether nitrogen would combine with a heated mixture of alumina and carbon or with products arising from the heating of such a mixture, and to study the best conditions for bringing about the reaction.

It was furthermore desired to investigate the conditions under which ammonia could be obtained from the resulting nitrogenous product.

That aluminium and nitrogen form a compound under certain conditions of the nature AlN or Al_2N_2 has long been known (*Zeitschr. Anorg. Chem.*, 54, 522-7, Fichte). This aluminium nitride is described as a gray amorphous powder. It is partly decomposed by water, forming ammonia, and this reaction also takes place on long standing in the air. Complete decomposition is effected by heating in alkali.

Ottokar Serpek was apparently the first to consider the possibility of applying the reaction of aluminous compounds with nitrogen to the fixation of atmospheric nitrogen. In numerous patents (U. S. A. Patents 888,044, 867,615, 987,408, 906,032; German Patents 181,991, 181,992, 183,702, 216,746; British Patents 13,579 (1906), 15,996 (1909), 25,141 (1911), in this country and abroad, he has covered the subject of aluminium nitride production, but without explaining much about the nature and conditions of the reaction. The chief point he makes is that a temperature of about 1800 deg. to 2000 deg. C. is essential, although in a more recent patent he mentions 1600 deg. to 1800 deg. C. as being permissible.

He works on mixtures of alumina or aluminous compounds with carbon, the materals being in a pulverized condition, claiming that this is better than aluminium carbide. This is in accordance with the theory of Caro (*Zeitsch. Angew. Chem.*, 23, 2412), that when aluminium nitride (AlN) is formed by heating aluminium carbide (Al_4C_3) with nitrogen, the reaction is due to the dissociation of Al_4C_3 to Al and C. Caro found in general that more nitrogen combined around 1150 deg. C. with Al_4C_3 if metallic Al was present than with pure carbide, and that the largest yield of nitrogen came when aluminium alone was heated. Very little nitrogen was obtained with pure carbide, as at this temperature the dissociation is small.

Serpek's method of producing aluminium nitride (AlN) was from bauxite and carbon passed through a revolving inclined tube in the walls of which was an electric resistance furnace. Nitrogen was passed through the tube as producer gas, and being ignited at the end of the tube, the gas is used to preheat the charge. He observed that an acid gas such as HCl or SO_2 in small amount seemed to help the reaction along, though why this should be is not exactly clear.

In the experimental work of the present authors pure nitrogen was used, obtained in the early experiments by passing commercial nitrogen through a combustion furnace containing heated copper gauze to remove the oxygen which was present to the extent of 7.2 per cent. In the later experiments, chemical nitrogen was used, prepared from NH_4Cl and $NaNO_2$. As a precaution, this too was passed over red hot copper. Thorough drying was effected by calcium chloride and concentrated sulphuric acid. These precautions were thought necessary, as oxygen would obviously have a bad effect by diluting the nitrogen, and by oxidizing the carbon in the charge; and water would absorb heat, and tend to increase the loss of carbon in the charge forming hydrocyanic acid. It was found that cyanogen formed in any case, but water increased the amount. Purified alumina was used, and the purest grade of petroleum coke, in all experiments except those on bauxite.

The bauxite used gave on analysis: SiO_2, 5.10 per cent; Fe_2O_3, 1.56 per cent; Al_2O_3, 53.76 per cent; ignition loss, 31.07 per cent; other substances (by difference), 8.50 per cent. From this the amount of Al_2O_3 in the residue after ignition was 78.00 per cent. The very large ignition loss is explained by the fact that bauxite contains a large proportion of water.

The first experiments of the authors were made in a wire-wound electric resistance furnace. In order to get higher temperatures they later employed a granular carbon furnace through which a tube passed for holding the charge, heated by a single-phase alternating current. At first several porcelain tubes were used, imbedded in the granular carbon resistor (Fig. 1). These porcelain tubes were found, however, inadequate to stand the sudden changes in temperature. The difficulty was overcome by using a graphite tube which was made with a bore of ⅝ in. diameter. The tube was provided with accurately fitted stoppers of graphite through which the nitrogen could be passed through metallic tubes threaded into the stoppers. The charge was contained in a graphite boat.

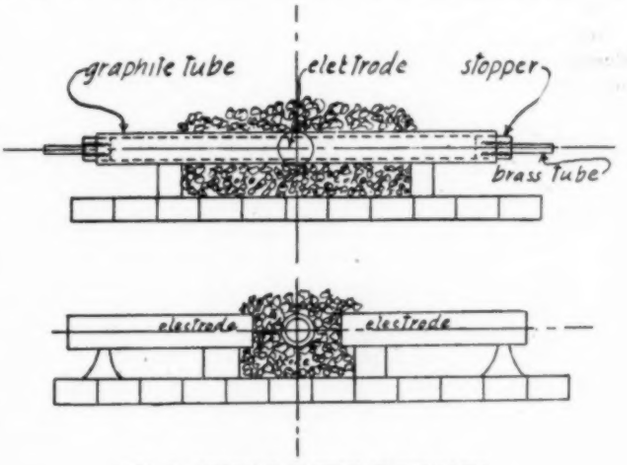


FIG. 1.—VERTICAL SECTION OF FURNACES.

The chief results are as follows:

Aluminium nitride (AlN) may be formed from Al_2O_3 and C in atomic ratio 1:3 or 1 part by weight of Al_2O_3 to 0.353 parts by weight of C. These would be the natural theoretic proportions from the equation.

$$Al_2O_3 + 3C + N_2 = 2AlN + 3CO$$

and they seem to be borne out by the experiments. Whenever the yield of nitrogen approached the theoretical 34.06 per cent the product was a nearly white amorphous substance with occasional particles of undecomposed carbon.

The temperature at which the reaction is carried on is evidently of prime importance. At lower than 1600 deg. C. the yield of combined nitrogen is trifling. Around 1800 deg. to 2000 deg. C., however, seems to be the right value as here was obtained the maximum amount of combined nitrogen, 30.19 per cent. But it is unsafe to go above 2000 deg. C. since decomposition of the nitride is liable to take place.

The time required for the reaction is comparatively short, but it is clear that there is a limit below which the reaction is incomplete as shown by two runs, 8 and 9, which were carried out under exactly the same conditions except that the former was strongly heated 15 minutes and the latter 30. The nitrogen in 8 was 6.11 per cent and in 9 was 9.57 per cent.

When there are impurities present, a greater length of time seems necessary. The question of impurities is very interest-

ing, as little is known about their effect. SO_2 in appreciable amounts is evidently harmful. Whether in minute traces, such as would be obtained in the producer gas from a good coal, the effect might not be better than appeared in this work of the authors is, of course, an open subject, but from a theoretical standpoint there would seem to be little reason for its use. The same would apply to HCl.

Producer gas as a source of nitrogen might be highly advantageous owing to its ability to burn and preheat the charge after it had been used in the reaction; and the further condition that oxygen should be absent is satisfied. Of course, the CO would have the effect of diluting the N, but the harm should not be serious with a plentiful supply of gas.

But impurities in the charge itself are apparently very useful, as is seen in the results on bauxite. This is probably due to catalytic action, of iron and lime particularly. It would seem that the effect of heating Al_2O_3 with C is first to produce nascent Al, which under ordinary conditions forms Al_4C_3.

But in the presence of fairly pure nitrogen the aluminium seems to have a greater affinity for nitrogen than for carbon. This would appear to agree with Caro's theory that aluminium carbide heated with nitrogen forms aluminium nitride by the dissociation of the carbide, after which the aluminium attaches itself to N. This is contrary to the former opinions of some writers who hold that it was the formation of the carbide that was a necessary preliminary to the formation of the nitride. But if the above theory is correct, obviously catalytic agents would be highly desirable, and they should be substances that form nitrogen compounds without great difficulty.

Another highly important point is that the gas should have means of easily getting in contact with the charge. Fairly fine crushing would seem to be a necessary condition for best results. Serpek's method of bringing about this contact was by the rotating cylinder previously mentioned. He would have the difficulty of obtaining a substance for the lining of this cylinder which could stand the high temperature and the abrasion of the charge passing over it. Carborundum might do it; so might silundum; possibly also magnesite, though it would undoubtedly wear out fairly rapidly.

As to the value of aluminium nitride as a commercial product, the ease with which ammonia can be formed is obviously the most important feature. It is well known that boiling alkaline solutions decompose it completely. Thus a source of commercial ammonia is evident, and connected with it a source of pure alumina that might well interest manufacturers of aluminium.

So far as its use as a fertilizer itself is concerned the last test described with the curve shows that it gradually evolves the nitrogen as ammonia from boiling water. If applied directly to the soil it might be expected to behave in a way not very different from this, which so far as its value as a fertilizer is concerned would be an advantage. The raw material bauxite is, however, probably too expensive to permit of its use in this manner and the nitrogen would have to be obtained as ammonia, so that the by-product alumina could be saved, either to use again in the process or in the manufacture of aluminium.

From the results of the necessarily brief set of experiments given, it is clear that, given suitable conditions, there should be no difficulty in producing a grade of aluminium nitride containing 30 per cent and more nitrogen. This should give the product an advantage over calcium cyanamid, which on the average runs from 17 per cent to 20 per cent fixed nitrogen.

Electric Resistivity of Fire Bricks at High Temperatures.

A paper by Prof. **A. Stansfield** and Messrs. **D. L. McLeod** and **J. W. McMahon** gives the results of experiments made at McGill University.

The materials tested were Caledonia firebrick, Star silica-brick, magnesite-brick, and chrome-brick, the last three being obtained from the Harbison-Walker Refractories Company. Cylinders 2 in. in diameter and about 2½ in. long were cut from these bricks, the length of the cylinder being the thickness of the brick. These cylinders were supported between disks of graphite of the same diameter, and contact was made between the cylinders and the disk by means of a paste of graphite and glue. In the first few experiments the apparatus was heated in a gas furnace, but this method of heating was found unsatisfactory, and electrical heat was then employed.

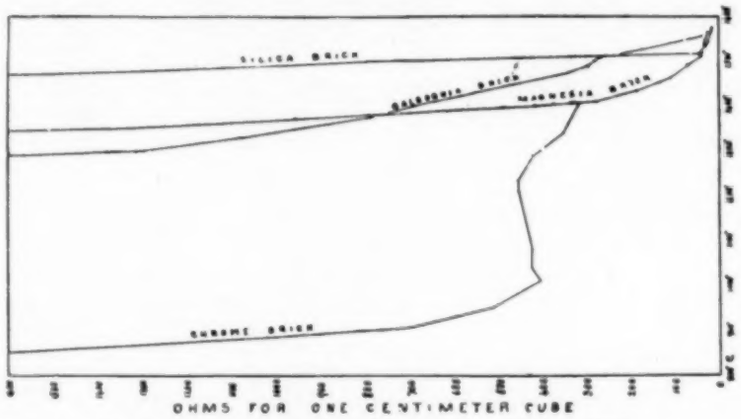


FIG. 2—CHARGE OF ELECTRIC RESISTIVITY OF FIRE BRICKS.

The results obtained from these experiments have been tabulated, and are also shown, in part, as curves in Fig. 2. It will be seen from these that at 1500 deg. C. the resistivity of all these materials is somewhat low. Comparing the results for the different materials, it wil be noticed that the silica and magnesia bricks, which approximate most closely to pure oxides, retain their insulating qualities to high temperatures, no considerable current being obtained below about 1300 deg. C. The firebrick and chrome brick, on the other hand, which are more complex in composition, begin to conduct at considerably lower temperatures. At the highest temperatures observed, about 1550 deg. C., the resistivities of all the bricks tested were about the same, being about 25 ohms for a 1-cm cube.

The accuracy of the readings was not very great, being limited by that of the ammeter for high resistivities and by that of the voltmeter for low resistivities. It is possible that the combined error would not be more than 5 per cent or 10 per cent for most of the readings, but increasing in the case of the higher figures, above 6000 ohms, to a maximum error of about 25 per cent at 21,000 ohms. It is doubtful whether the higher temperature readings are to be depended on within about 20 deg. C., although the relative error in the readings would be less than this.

The results obtained for the chrome brick are very peculiar. This was not noticed until it was too late to repeat the observations, and they should therefore be regarded as subject to correction.

In connection with these results it is interesting to allude to a few figures which have already been published in this connection. Reference may be made to a paper by H. M. Goodwin (*Transact.*, Am. Electrochem. Soc., Vol. 9, p. 89, 1906) on the physical properties of fused magnesium oxide. The electrical resistivity of this oxide was tested and was found to be 380,000 ohms for a centimeter cube at 1150 deg. C., which was the highest temperature reached. Landlot and Börnstein give the resistivity of magnesia at 1500 deg. C. as 12,000 ohms for 1 cm. cube, and that of zirconia as 1200 ohms at 1200 deg. C. These figures are very much higher than the authors have obtained for firebricks, but it may be mentioned that MgO + 10 per cent B_2O_3 at 1250 deg. C. has a resistivity of 83 ohms. On

the other hand, porcelain at 1000 deg. C. has a resistivity of 330,000, according to Nernst-Reynolds, and Goodwin gives values of 1,000,000 ohms at 1000 deg. C. and 780,000 ohms at 1100 deg. C., which seem very high in view of the figures the authors obtained for firebrick.

The results give the averages of a number of tests which were in most cases quite concordant. It would be desirable to extend the work to higher temperatures and to use test-pieces of different dimensions.

OHMS FOR 1 CM. CUBE.

Temperature.	Caledonia Firebrick.	Silica Brick.	Magnesite Brick.	Chrome Brick.
600 deg. C.	21,000	....	....	....
700 deg. C.	17,000	....	....	....
800 deg. C.	13,000	....	....	2800
900 deg. C.	9000	....	....	760
1000 deg. C.	6600	....	....	420
1100 deg. C.	4400	....	....	430
1200 deg. C.	2300	....	....	450
1300 deg. C.	1300	9700	6200	410
1400 deg. C.	690	2400	420	320
1500 deg. C.	280	710	55	....
1550 deg. C.	60	22	30	....
1565 deg. C.	....	18	25	....

Electrolytic Refining of Silver-Bismuth Alloys.

A paper by Dr. **William N. Lacey** gives the results of an experimental investigation carried out at Leland Stanford University on the electrolytic separation of silver from bismuth from the binary alloys.

Three alloys were made; A containing 65 per cent of silver and 35 per cent of bismuth; B, 2.8 per cent silver and 97.2 per cent of bismuth, and C 53 per cent silver and 47 per cent bismuth.

Electromotive force determinations were made for alloys "A" and "B" in each of the two electrolytes, *i. e.*, cyanide of silver and nitrate of silver, using metallic silver as the other pole of the cell. The results obtained are shown in the following tabulation:

Electrolyte.	Positive Pole.	Negative-Pole.	E.M.F. of Cell—Volts.
Cyanide	Alloy "A"	Silver	0.202
Cyanide	Alloy "B"	Silver	0.242
Cyanide	Bismuth	Silver	0.173
Nitrate	Silver	Alloy "A"	0.591
Nitrate	Silver	Alloy "B"	0.448
Nitrate	Silver	Bismuth	0.288

"The difference in polarity of the two alloys in the two solutions is probably due to the fact that there are relatively few silver ions present in the cyanide electrolyte as compared to the nitrate electrolyte. The lower results obtained in using pure bismuth may be accounted for by heat being absorbed in the formation of the alloys, thus giving them a higher emf."

Experiments were then made on the separation of the silver from the bismuth using either a cyanide electrolyte or a nitrate electrolyte.

The "cyanide electrolyte" was prepared by adding a 5 per cent solution of potassium cyanide (KCN) to a 5 per cent solution of silver nitrate ($AgNO_3$) until the precipitate dissolved. Just enough of an excess of cyanide solution was added to keep any silver cyanide from forming during the electrolysis.

The "nitrate electrolyte" is the one used in the United States Mint at San Francisco in the electrolytic refining of silver bullion. It was a solution containing 3 per cent silver, as silver nitrate, and 2 per cent of free nitric acid.

The results of these experiments are given in extended tables and diagrams. The chief conclusions are summed up as follows:

Results Obtained with the Cyanide Electrolyte:

(*a*) A deposit of silver containing less than 1 per cent of bismuth may be obtained by using a current having a normal density of 100 sq. cm. of not more than 0.14 amp. The current density gradually decreases during the electrolysis. All current density results are approximate, due to the uncertainty of cathode surface measurements.

(*b*) The potential difference between the electrodes gradually increases through a small range, during the electrolysis, but may safely be as high as 6 volts.

(*c*) The required energy input is about 0.25 kw-hour per pound of silver deposited for a potential difference of 1.5 volts. This value is increased by 0.11 kw-hour per volt of increase in the potential difference.

Results Obtained with the Nitrate Electrolyte:

(*a*) The silver deposits had comparatively high bismuth contents, even for low current densities. The results showed no great regularity.

(*b*) The potential difference between the electrodes must be kept down almost to the emf force of the cell in order to get a good separation.

(*c*) The required energy input, expressed in kw-hours per pound of silver deposited, is about 0.06 for a potential difference of 0.5 volt. There is an increase of 0.15 kw-hour for an increase of 1 volt in the potential difference.

Comparison of the Two Electrolytes:

(*a*) The nitrate electrolyte demands a weaker current, which calls for a much larger electrode surface for the same rate of deposit.

(*b*) The percentage of bismuth in the cathode deposits is more irregular and uncertain for the nitrate electrolyte, possibly due to colloidal conditions in the anode slimes.

(*c*) The necessary energy input increases more rapidly for higher voltages in the nitrate electrolyte than in the cyanide electrolyte.

(*d*) The deposit from the cyanide electrolyte is quite adherent, and the use of anode bags is avoided. The bismuth content of the deposit, using the cyanide electrolyte, is small enough to be gotten rid of in the melting, without occasioning a large loss.

Causes of the Practical Non-Success of Electric Furnaces in Treating Zinc Ores.

BY FRANCIS LOUVRIER.

For years past the application of electrical energy to the economical treatment of ores has been the desideratum the most sought after. Especially is this the case with respect to the electrical treatment of zinc ores, due to the high cost and the low yield of the present process.

The success of the inventors so far, however, seems not to have been commensurate with the time, study, research, and experiments devoted to it, as, until now, no electric furnace has given sufficiently satisfactory results to warrant its adoption as an economical substitute for the present method, and that despite the latter's numerous defects.

This lack of success seems somewhat inexplicable, especially as, excepting the manner of heating the ores (externally in the present system, internally in the electric furnaces), the inventors of the latter have copied the actual process of distilling the zinc, as well as adopting the same chemical reactions as developed in the ordinary retorts, which yield sufficiently satisfactory results.

Notwithstanding this, however, all experiments undertaken so far have been characterized by an unsatisfactory condensation of the zinc vapor, a considerable portion of the zinc obtained being produced in the form of blue powder instead of molten metal. This fact of the production of blue powder which does not take place in the ordinary retorts, or, if it does, in very small quantities, is due to the formation in the electric furnaces of a much higher percentage of carbon dioxide than in the usual retorts.

Although the various inventors and experimenters may have believed that in their experiments they fulfilled all the con-

ditions to which the zinc oxide is submitted in the ordinary retorts, the different results obtained prove the contrary.

As in this case, the electric current is "chemically neutral" and does not affect the reduction of the zinc oxide, it must be deduced that the conditions to which the same substances are submitted are different in each case. To ascertain of what this difference consists, research has been undertaken by the writer, with the result that he has arrived at the following conclusions.

It is well known that, in accordance with the formulas given hereunder, two operations take place in the reduction of zinc ores:

$$(1)\ ZnO + CO = Zn + CO^2$$
$$(2)\ CO^2 + C = 2\,CO$$

The final products are zinc in the form of vapor, and carbon monoxide; but there is an intermediary production of carbon dioxide, which, in the presence of carbon at a high temperature, reacts to form carbon monoxide, this latter reaction taking place at a lower temperature than the former.

In an ideal reduction all the carbon dioxide should be converted into carbon monoxide. Unfortunately, in practice, this is not the case, and especially not in electric furnaces, in which, in every instance, there has been found the formation of a high percentage of carbon dioxide mingled with the zinc vapor. It is clear that this high percentage is the result of the incomplete manner in which the last named reaction occurred, i.e. the transformation of carbon dioxide into carbon monoxide.

This, therefore, induced us to investigate the causes which create this incomplete transformation.

In ordinary retorts, due to the slowness in which the reduction of the zinc oxide is effected, and to the slight production of carbon dioxide which results from it, as well as to the uniformity of temperatures, the conversion of the carbon dioxide into carbon monoxide takes place almost completely and without difficulty, *because the contact of the carbon dioxide with the hot carbon reducer occurs during a relatively long period*. The result is, therefore, that there passes to the condenser, mixed with the zinc vapor and the carbon monoxide, a very small percentage of carbon dioxide, insufficient to alter in any way the zinc vapor or create any disturbance in the condensation.

In the electric furnaces that have been used to experiment with the treatment of zinc ores, the conditions under which this conversion took place, are different, as will be shown later. To date, these furnaces have been either of the arc or the resistance type. In this last named class the current passes through a resistor constituted either of carbon, or a bath of slag, or between two electrodes dipping into the charge to be treated. In each case the furnace had a zone directly heated by the current and very limited, which consequently, was at a much higher temperature than that required for the reduction of the zinc oxide.

If the furnace had a relatively large capacity, the part outside of the zone traversed by the current would have remained at a comparatively low temperature; so that the following took place:

Within the directly heated zone, the reduction of the zinc oxide took place rapidly and was accompanied by a great production of carbon dioxide which, escaping to the higher part of the furnace, almost immediately entered a comparatively cold zone, too cold to permit, when it came into contact with the carbon, its complete transformation into carbon monoxide. The consequent result was that only a small portion of the carbon dioxide was converted into carbon monoxide, due to deficient contact with the hot carbon reducer.

In other electric furnaces in which experiments were made their capacity was too small, the entire contents being carried into a strong incandescence, so that the carbon dioxide resulting from the reduction of the zinc ores encountered, while escaping, an insufficient quantity of carbon, as well as too high a temperature, to permit its complete and normal transformation into carbon monoxide.

From these considerations the following conclusion is arrived at:

The presence of carbon dioxide, in large quantities, in the actual electric furnaces is due, at least in its greatest part, to the rapidity in which the reduction of the zinc ores takes place, which creates a too active production of carbon dioxide in a limited space, so preventing this gas from coming into contact with the carbon reducer during the time required for its reduction. This rapidity is caused by the too high temperature which results from the smallness of the zone in which the effects of the electric current are directly felt.

Be this the case, the amount of carbon dioxide and, consequently, the quantity of blue powder produced in electric furnaces, must be in proportion to the maximum temperature in the furnace. This is precisely what actual electric practice has demonstrated, seeing that the arc furnaces produce more blue powder than the resistance furnaces, and in these latter, when either accidentally, or from lack of care, an arc is formed, a disturbance is at once perceived, which is accompanied by a more abundant production of blue powder.

Another fact tends to confirm the accuracy of our assumption. In all experiments made to date with electric furnaces, the presence of notable quantities of carbon and ore dust in the condensers has been observed. As the presence of carbon and ore dust can only be explained by an outrush of gas and vapor strong enough to carry out this dust, it must necessarily be admitted that the production of gas and zinc vapors is too rapid in the furnaces, and that, therefore, the contact of the carbon dioxide with the carbon reducer cannot take place during the time required to convert it into carbon monoxide.

Furthermore, other causes contribute to increase the percentage of carbon dioxide in the electric furnaces, as, for instance, the vertical disposition of the movable electrode. It is clear that the reduction of the zinc oxide is more active where the temperature is highest, that is, in the zone in contact with the electrode. Consequently, in the immediate vicinity of the electrode the production of carbon dioxide is particularly abundant. As the electrode operates within a small open or free space (formed to permit its movement, as well as naturally, by the descending charge which is coning down toward the electrode) a notable quantity of the carbon dioxide produced escapes through this free space without meeting any of the carbon reducer to transform it into carbon monoxide.

Various methods have been suggested and attempted to prevent the formation of large quantities of carbon dioxide in electric furnaces. These consist in forcing the gases and vapor, which escape from the furnace, to pass through a column of incandescent carbon. These remedies, however, have not given any radical results. They have the defect of working too tardily, and, therefore, are only palliatives. It is in the furnace itself, not outside of it, that the conversion of the carbon dioxide into carbon monoxide must take place.

The inevitable deduction from the foregoing is that the high percentage of carbon dioxide found in the electric furnaces used until now is due entirely to the ineffective disposition of these furnaces, which are not arranged to allow the performance of the necessary chemical reactions. As these reactions yield sufficiently satisfactory results in ordinary retorts, the fault evidently lies in the defective physical arrangements of the electric furnaces in which the experiments were made. To remedy these defects seems more to lie within the province of the electrician than the metallurgist. The remedy would therefore appear to come in devising some new manner of conducting the electric current in the furnaces, and dividing the current as uniformly as possible among all the charge contained in the reduction zone of the furnace, instead of

concentrating it, as at present, in the confined space comprised between the two electrodes.

We are thus led to indicate the improvements that are necessary to render the electric furnace efficient, or, rather, the conditions to be filled.

1. An electric furnace to treat zinc ores must contain a zone of reduction in all parts of which the temperature must be more or less uniform, but not too high, so that the reduction of the zinc oxide may take place slowly and with equal intensity in any horizontal section of the furnace.

2. This zone of reduction must be large enough to compel the zinc oxide to remain at the necessary temperature during the time required for its complete reduction, which must be effected as slowly as possible, and as well permit the slow escape of the carbon dioxide, so that it may enter into contact with the hot carbon for the time necessary to transform it into carbon monoxide, and, furthermore, prevent any outrush of gas and vapor which would be capable of carrying dust into the condensers.

3. The height of this reduction zone must be sufficiently great to permit the carbon dioxide to be entirely converted into carbon monoxide in meeting, on its escape, a layer of ore and carbon at the necessary temperature, and, above all, thick enough to allow a sufficiently long contact.

4. The temperature in the reduction zone (principally when treating complex ores containing other metals, such as lead or copper), although uniform in a horizontal section, should be gradually increased as the floor of the furnace is reached, in order that the reduction zone of the zinc oxide may not be the same as the reduction zone of the lead and copper.

This can be practically thus obtained: the upper part of the reduction chamber being more or less at 1050 deg. centigrade, i.e. at the reducing temperature of the zinc oxide, while the lower part remains at 1200 deg. or 1250 deg. centigrade, the normal temperature for the reduction of lead or copper ores.

In this way the carbon dioxide resulting, for instance, from the reduction of the lead ores, has to traverse a thick layer of charge containing the hot carbon, which transforms it into carbon monoxide before mingling with the zinc vapor formed in the upper part of the reduction zone.

5. In the zone of reduction there should be no free space through which the carbon dioxide can escape without first having come into contact with the hot carbon reducer. This, as stated, will exclude the employment of movable vertical electrodes inserted into the charge to be treated.

Besides these essential conditions, conditions which in the furnaces hitherto employed have never been realized, it is clear that, with a furnace adapted to treat zinc ores, it must also fulfill the following requisites:

(a) It must be completely closed to prevent the entrance of air, at least in the reduction zone.

(b) It must be arranged in such a way that the charge will reach the reduction zone already sufficiently heated so that all water, air, etc., have been completely expelled.

(c) The carbon monoxide produced should be recovered, so that it may be again utilized, as, for instance, to roast the ores when these are blende or calamine.

(d) It must be arranged for continuous working.

We do not conceal from ourselves the difficulties to be overcome in establishing a furnace that will meet the conditions indicated above. But as to know the causes of an evil is to have effected half its cure, so we have thought that by exposing the origin of the defects, as these appear to us and as outlined above, we may have indicated the paths to be followed, to encounter, finally, a practical solution of the perplexing problem, How to secure the economical treatment of zinc ores.

Mexico City.

Notes on Chemistry and Metallurgy in Great Britain.

(From Our Special Correspondent.)

The British Association.

The eighty-second annual meeting of the British Association which was opened at Dundee on September 4 will probably rank as one of the most memorable gatherings of scientists. The attendance on the first day, when Professor Schafer delivered his address on the nature, origin and maintenance of life, considerably exceeded all previous figures and numbered 2379.

In his presidential address to the Engineering Section Professor Archibald Barr advocated a "closer connection than was usually recognized between the work of the engineer and that of those to whom the title of artist was usually restricted; and in addressing the Chemical Section Professor A. Senier emphasized the value of research work and the advantages of providing greater facilities for its prosecution by capable men. "The object and ideal," he said, "is wrong also in our system of technical training. We aim too much at giving elementary instruction to artizans, which, though important in itself, can never take the place of the higher education of leaders or managers of industrial works." In the Mathematical and Physical Science Section Professor Callendar dealt with what he termed the "re-discovery of caloric," and said it would be advantageous to supplement the kinetic theory of heat with some of the ideas of the old—he should have said "exploded"—material caloric theory. Not content with this, he proceeded to express a preference for regarding *molecules* of caloric as being composed of positive and negative *corpuscles* of electricity, *"in much the same way as a molecule of hydrogen is formed by the union of two atoms."* He further actually spoke of the *weight* of "caloric." Unpalatable as this attempt to treat force as a material substance must have been to most, if not all, physicists present, yet his eulogy of Carnot was received as a worthy tribute. After this it was not greatly surprising that Professor Bragg, in an evening address on "Radiations, Old and New," should have expressed the opinion that Newton's *particles* of light might, perhaps, be discovered in the emanations from radio-active matter, and that it was not impossible that modern science would draw together the corpusclar and wave theories of light.

Truly, the study of radio-activity is bringing forth a promise of rare and refreshing fruits. Will they prove better than Dead Sea Apples?

Deterioration of Aluminium Alloys.

In the Engineering Section of the meeting of the British Association at Dundee early in September, Professor Ernest Wilson read a report on "Exposure Tests of Light Aluminium Alloys." He said that reports presented to the British Association during the last eleven years showed that alloys of commercial aluminium with copper only were not satisfactory, and a 2.6 per cent copper alloy had completely deteriorated in ten years, and its electrical resistance had increased 25 per cent. The alloys under investigation were in the form of wire, 0.126 in. in diameter, and were suspended on the roof of King's College, London, to ascertain the effect of such exposure on their electrical conductivity. The addition of iron, nickel and manganese to the low copper alloys had been found to increase both the tensile strength and the resistance to deterioration. With specimens containing, respectively, 1.16 per cent of iron, 2.25 per cent of nickel, and 1.78 per cent of manganese the electrical resistance had only increased about 9 per cent in eleven years. "Duralumin" was a copper-manganese-aluminium alloy, plus about 0.5 per cent of magnesium, and after one year's exposure a specimen, some 80 ft. long, had increased 5.15 per cent in electrical resistance. Was this due to the comparatively high percentage of copper (3.5 to 5.5) or was the manganese (0.5 to 0.8) too low? By suitable treatment this alloy could be obtained with a very high breaking load—up to 90,000 lb.—but its electrical specific resistance was about twice that

of commercial aluminium. The electrical resistance of high-conductivity copper had been found to increase only 1.2 per cent after one year's exposure.

In the discussion, Mr. Arnold Lupton asked if there were any notable amount of salt in the atmosphere at King's College. It was well known that the destructive effect of salt on aluminium and its alloys was very great.

Professor Petavel asked if tests had been made of the effect of exposure on the mechanical properties of the specimens. Such tests would be very valuable to aviators who were inclined to give up these light alloys and revert to steel, in spite of its weight being five times as great, not because it was known that these alloys would deteriorate say 10 per cent in a year, but because there was uncertainty as to the extent to which their uniformity could be relied on. A known depreciation could be allowed for; but the irregularity in the properties of many alloys was a more serious matter. Duralumin at its best might have the lightness of aluminium with the strength of steel; but unfortunately it was extremely sensitive to heat treatment. The difficulty of soldering aluminium was a source of trouble, and there was danger that moisture might cause rapid deterioration at the joints.

Professor Wilson replied that the atmosphere at King's College was practically free from salt but contained sulphur. It was recognized that aluminium deteriorated rapidly in the neighborhood of salt water, and was unsuitable for power transmission lines in such situations. He regretted that the limited number of his specimens, which he did not wish to destroy, had not allowed him to take physical tests. He agreed that there was danger in soldered aluminium joints, and deprecated the use of any other metal than aluminium alone for jointing.

In connection with this subject your correspondent would point out that, as far as is known, attention was first drawn to the spontaneous disintegration of aluminium alloys by the late Sir W. Roberts-Austen in the Third Report of the Alloys Research Committee, which embodied the results of his research in 1895 on the melting points of the iron-aluminium alloys. In a paper read before the Faraday Society in June, 1910, on "The Failure of Light Engineering Alloys, particularly the Aluminium Alloys," E. F. Law stated that it had since (1896) been shown that spontaneous disintegration occurred with most of the other aluminium alloys, including those with nickel, cobalt, antimony, manganese, molybdenum and even zinc. He established the fact, which Roberts-Austen does not appear to have observed, that disintegration is preceded by marked expansion; and went on to say, "It is interesting to note that chilling appears to prevent the disintegration. A particular alloy was found to disintegrate in three weeks when allowed to cool in the crucible, whereas samples of the same alloy, made at the same time, and with the same materials, but cast in an iron mould, have been in the author's possession for eight years and show no signs of disintegration." It is now recognized that disintegration may, in some cases, be prevented or greatly retarded by putting work upon the alloys soon after their manufacture.

Dr. Rosenhain's researches on the aluminium-zinc alloys published in the last-issued Report of the Alloys Research Committee throw further light on the matter; but—as your correspondent remarked soon after the report was published—the statement in the text that the alloys did not appear to undergo change of properties with ageing is not consistent with the tabular test figures given.

Engineering Imports and Exports.

The returns issued by the Board of Trade for the eight months ended on August 31, show a satisfactory all-round improvement as compared with the figures for the corresponding period of last year. Imports of iron and steel, including manufactures, are valued at £8,062,227, an increase of £692,553; and exports are put at £29,896,894, an increase of £1,291,854. Other metals, including manufactures, were imported to the value of £19,893,807, and exports reached £7,498,416, the respective increases being £1,733,274 and £426,667. In electrical goods the imports amounted to £921,807, an increase of £34,592, and exports were £2,712,414, an improvement of £930,894. Imports of machinery reached £4,506,817, an increase of £522,148, and exports touched £21,181,719, a rise of £764,257. Imports of new ships totaled only £24,907, showing a decrease of £31,889, while the exports were £3,712,249, a gain of £8,768. The returns for August taken by themselves against those for August, 1911, give an increase of £316,090 in imports of iron and steel, and a rise of £937,527 in exports; imports of other metals were £630,322 higher and exports improved by £265,376; in electrical goods imports rose £11,177 and exports were £113,281 better; machinery imports went up £116,087, and exports increased by £268,584; ships show an increase of £635 in imports and exports rose £94,360.

The Use of Compressed Oxygen in Estimating Carbon in Ferro-Alloys.

P. Mahler and **E. Goutal** (*Compt. Rend.*, 1912, 154) have succeeded in estimating the carbon in the most refractory ferro-alloys by the calorimetric bomb method. In addition to the litharge flux required for very hard steels these alloys demand an auxiliary combustible, and the authors employ iron of ascertained carbon content. In the case of very high carbon alloys more than 0.5 gr. would be an inconvenient quantity, and the amount of added iron must be increased to bring the total charge to about 3 gr. in order to avoid difficulty in securing complete combustion, while the litharge used should be half the weight of the combustible charge. A determination without any alloy is made to ascertain the correction for the carbon in the additional iron and for constant errors.

The carbon dioxide is absorbed by sodium hydroxide and its amount is determined by titration before and after the combustion. The authors' results go to show that when this method gives figures appreciably differing from those obtained by direct dry combustion the figures are always higher. For instance, a 69 per cent ferro-chrome gave 9.7 per cent of carbon by direct combustion, and 10.6 by the bomb method; a 75 per cent ferro-silicon gave 0.11 per cent by the direct method and 0.2 per cent with the bomb. The authors consider that with these alloys their higher figures are probably more trustworthy. Ferro-molybdenum and ferro-vanadium give very concordant results by both methods.

Market Prices.

Copper opened at £78-18-0 and remained steady to rather lower during the first half of the month, since inclined to improve, and closes at £79.

Tin opened at £218-5-0 and was up to £226-10-0 on the 16th and 19th, reached £228-10-0 on the 24th, and closes £231.

Lead opened at £20-15-0 and rose to £23-5-0 by the 10th, afterwards easing slightly, but still at £23 on the 19th; quieter towards the end of the month, it closes at £22-15-0.

Cleveland was 63/7 at commencement of the month, 65/- on the 7th and 67/6 on the 19th; had eased to 67/1 by the 24th and closes at 67/6.

Haematite has risen during the month from 77/9 to 81/9.

Scotch Pig has also risen considerably from 67/7 to 72/9.

	£ s. d.
Alum, lump, loose, per ton	5.15.0
Antimony, black sulphide powder, per ton	20. 0.0
Borax, British Refined Crystal, per ton	17. 0.0
Copper Ore, 10 to 25%, per unit	14/1½ to 14.7½
Copper Sulphate, per ton	24.17.6
Carbolic Acid liquid, 97/99% per gal.	1.6½
Creosote, ordinary good liquid, per gal.	3¼
Camphor, 1 oz. tablets	1.7¼
Caustic Soda, Ash, 48% ordinary, per ton	5.10.0
Hydrochloric Acid, per cwt.	5.0

India Rubber, fine Para	4.7
Mica, small sheet, original cases, per lb.	6d. to 3/-
Naptha, solvent, 90%, 160° C. per gal.	1.2
Petroleum, Russian spot	7⅝
Quicksilver, per bottle	8. 5.0
Sal Ammoniac, lump, firsts, delivered U.K. per ton	44. 0.0
Sulphate of Ammonia, f.o.b. Liverpool, per ton	14.17.6
Sulphur recovered, per ton	5. 5.0
Shellac, standard T.N., Orange Spots, per cwt.	4. 4.0
Tin Ore, 70% per ton	147 to 149. 0.0
Zinc, Vielle Montagne, per ton	30.12.6
Platinum, nominal, per oz.	9. 5.0

Higher.

	£ s. d.
Copper Sulphate	17.6
Sulphate of Ammonia	7.6
Tin Ore	11. 0.0
Zinc, V. M.	17.6
Cleveland (Iron)	3.2

Lower.

India Rubber (Para)	6

Recent Chemical and Metallurgical Patents.

Iron and Steel.

Briquetting.—WARREN R. VALENTINE of Ford City, Pa., has patented a method of briquetting borings, turnings, etc., for charging into furnaces, mainly cupola furnaces, in such a way that the briquets do not disintegrate before the metal melts. The binder remains effective as such up to a temperature equal or approximately equal to the melting point of the metal. The same binder can also be used with beneficial effects in forming briquets from ores and other material where integrity of the briquet at high temperature is required. The borings, etc., of iron, steel, etc., are first mixed with a finely divided fluxing material as limestone, fluorspar, etc., in the proportion of 50 lb. of flux to a ton of the material. This mixture is dampened with a solution of glutrin and soda ash or other material capable of combining with the rest with the generation of heat. While the bond is effected the temperature goes up to 100 deg. F., if the briquets have a large radiating surface, and up to 150 deg. F. in from 24 to 36 hours, when piled together. This internal heating makes the briquets hard and capable of being charged into a cupola without the employment of external heat. From 10 per cent to 15 per cent of these briquets can be charged with the heat, in ordinary foundry practice as high as 30 per cent and with light castings as high as 20 per cent can be used. (1,024,428, April 23, 1912.)

A method of reducing iron ore has been patented to the well known Swedish inventor GUSTAF GRÖNDAL. An inclined cylindrical furnace rotates and carries the intimate mixture of iron ore and carbon against the uprising flow of heating gases. These gases can, but need not be, of a reducing character in which case the amount of solid carbon can be decreased. In case the gas or gas mixture is chemically indifferent and merely acts as a carrier of heat (at about 800 deg. C.), the best proportion of carbon has been found to be 20 per cent of the iron contained in the ore. The mixture is preheated and dried by part of the used gases and fed into the rotating tube by a screw conveyor. At the lower end of the furnace the iron drops automatically into cars on trucks. The reduction process increases the amount of gases passing through the furnace and the excess is led away and used for heating the recuperator at the discharge end of the system. The heating of this recuperator, however, is principally effected by producer gas specially produced for this purpose. The bulk of the gases is forced by a blower through the recuperator and back into the furnace. The furnace and various ways of connecting the gas mains are illustrated by drawings. (1,033,051, July 16, 1912.)

Converter-Electric Steel.—The old idea of accomplishing the oxidizing and the electrical refining of steel in one and the same furnace is brought forth in a new variety of apparatus by HENRY JOHNSON, Sheffield, England. A double-ended converter of approximately cylindrical shape adapted to be rotated end over end is suspended in trunnions and provided with tuyers at one end. These tuyers passing through the side or through the end itself may be horizontal or vertical. The other end of the converter is fitted with means for refining and finishing, for instance, a number of electrodes connected to direct or alternating single or multiphase current. The converter is rotated about an axis which is at right angles to that of the vessel in order to bring either side into operative position. Charging and teaming in the usual way are described in detail. (1,032,217, July 9, 1912.)

Hot-Blast Stove for Heating Air, Steam or Other Gases.—The present hot-blast stoves used in heating the air for blast furnaces suffer much from alternate heating and cooling of the firebricks and consequent expansion and contraction. The highly heated flues are liable to lose shape and soot settles on all possible surfaces of the brickwork. FRANK C. ROBERTS of Wynnewood, Pa., has designed several shapes of bricks intended to overcome this trouble and to allow a quicker cleaning out of the stove. His bricks show recesses and projections of same thickness as the brick itself, either recess and projection on each brick or only two projections or only recesses. A number of cuts illustrate the variety of ways to join the different bricks (one type at a time in one furnace) together. (1,032,505, July 16, 1912.)

Purifying Iron and Manufacturing Steel.—Three patents have been granted to HERMAN A. BRASSERT, application for which was filed as early as November, 1904. The main feature of all three inventions is to run the iron from a blast furnace into some vessel, preferably of a size large enough to hold from 50 to 200 tons of metal. This vessel is provided with tuyers, through which the hot blast or cold blast can be directed onto the surface of the metal. By means of this blast the sulphur, phosphorus, silicon and if so desired, the carbon can be removed. The heats developed by these reactions is sufficient to keep the metal liquid, in fact the heat is sometimes increased beyond the requirements, and it is necessary to regulate the pressure of the blast, or to use the cold blast instead of the hot one. By thus regulating the air blast the heat of the bath can be varied at pleasure. This offers means to oxidize the phosphorus at the low temperature which is desirable for this purpose. It is claimed that by using the above described process, iron can be purified and afterwards used for steel making in a more rapid way than known before, or the iron can be transformed into steel in one operation in this same vessel. The inventor thus intends to dispense entirely with the use of converters, mixers, and open hearth, and with the different operations of transferring the metal in ladles from one furnace to another. (1,032,653, 1,032,654, 1,032,655, July 16, 1912.)

Disintegrating Nodulizer-Kiln Rings.—When pyrites cinder, fine iron ore, furnace flue dust, and the like are agglomerated in a rotating nodulizing kiln, there is a tendency for the material to form a ring within the kiln near the discharge end. If this ring is allowed to grow it will ultimately prevent the discharge of material from the furnace, and some means must be adopted to break it. In Fig. 1 we illustrate a device for this purpose, patented by Mr. JAMES W. SHOOK, of Tuscaloosa, Alabama. The figure shows the discharge end of a kiln, and two views of the disintegrating harpoon.

The ring of furnace stock is shown at *F*. The harpoon *H* has a chisel edge attached to a supply pipe *G*, which has a flexible connection *J*. Discharge holes *KK* are placed in the bottom face of the harpoon. To remove a ring of sintered material the disintegrator is passed through one of the port holes in the hood *D* and the chisel edge of the harpoon is forced under the thin edge of the ring against the brick lining *E*. At the same time a stream of water is forced through the supply pipe

and out of the holes *KK*. The sudden vaporization of the water breaks the ring and this process is repeated until a cut is completed across the ring, after which the rotation of the kiln will shake the remainder of the ring loose. (1,035,754, Aug. 13, 1912.)

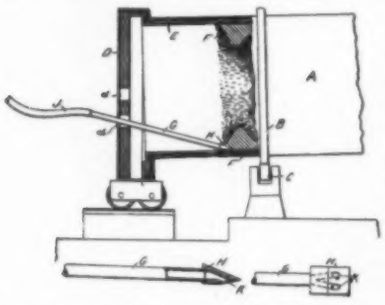


FIG. 1.—DISINTEGRATING NODULIZER KILN RINGS.

Improved Channel Furnace.—An invention relating to furnaces of the Grondal type is illustrated in Figs. 2 and 3, being part of a patent granted to Mr. JOHN W. H. HAMILTON, of St. George, N. Y., and assigned to the American Grondal Company, of Uew York City. It relates to the construction of the cooling chamber and preheating air passage above the same and to a novel sealing means for maintaining the space above the trucks separated from the air space below them.

In channel furnaces of the Grondal type, it is common practice to preheat the air for the burners by passing it through a passage above the crown of the cooling chamber. Additional heat is extracted from the glowing briquets by passing a stream

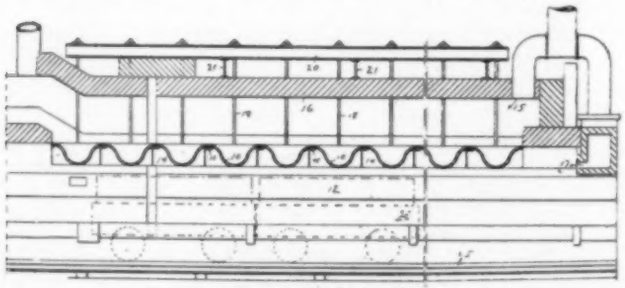


FIG. 2.—IMPROVED CHANNEL FURNACE.

of air over them. Fig. 2 shows a longitudinal vertical section of the improved furnace and Fig. 3 gives a detail of the construction of the crown of the cooling chamber. Instead of the usual crown arch of brick between the side walls of the furnace, the inventor substitutes a roof of a series of metallic castings of the form shown in Fig. 3. These rest at opposite ends on the sides of the furnace and form an undulating metallic ceiling, shown in dark outline in Fig. 2.

The blast of air that flows from the port 13 directly over the briquets 12 on the truck *E*, enters the recesses of the undulatory surface and is deflected down on the briquets. In this manner the air is more highly preheated and the briquets more thoroughly cooled than formerly. Likewise the blast of air entering at the port 15, passing above the roof plates 10, is confined by the roof arch 16 and spreads over the hot roof plates, absorbing a great amount of heat and reaching the burners at a higher temperature than has been attained in former construction.

FIG. 3.—DETAIL OF ROOF, CONSTRUCTION OF CHANNEL FURNACE.

The roof plates 10 are strengthened by longitudinal ribs 17 and are supported also by rods which are hooked into the eyes 19, and attached to the beam 20.

In order to seal the spaces above and below the trucks, the latter are provided with side fins which dip into continuous water troughs extending along the sides of the channel. To obviate the necessity for valve devices at opposite ends of the troughs to permit the entrance and exit of the fins, the track on which the truck runs is inclined slightly at each end of the furnace, so that the fins just dip into the troughs at the ends of the furnace, and are at their deepest point during the travel of the truck through the combustion chamber where the need of the seal is greatest. (1,035,699, Aug. 13, 1912.)

Converter Construction.—Converters usually are constructed with the body or shell permanently secured to the air-box and trunnions, so that the latter parts have to be removed with the shell when it is out of service for relining or any other purpose. A new method of construction patented by Mr. ALEXANDER ZENZES, of Berlin, Germany, and assigned to the Zenzes Converter Company, of Chicago, provides a shell which is detachable from the air-box and trunnions so that the latter may remain in service when the shell has to be removed.

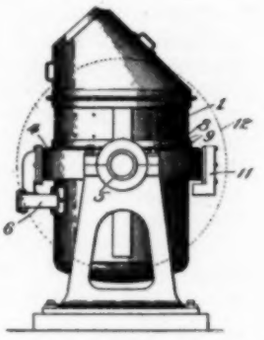


FIG. 4.—IMPROVED CONVERTER CONSTRUCTION.

By reference to the drawings, Figs. 4 and 5, it will be seen that the shell is constructed in the usual manner, but is supported on the air-box 4 by an encircling angle-iron 8. The air-box and trunnions are pivoted on supports 3. When the shell is placed in position, resting on the air-box, a downward extension of the latter, 6, forms a passage between the air-box and the tuyeres 7, and the several openings are designed to register perfectly and prevent the escape of air. A cover 11 is provided at the right-hand side of the air-box, and being of heavy construction it serves also as a counterweight for the shell. By this construction a damaged shell may be removed from the air-box and trunnions and its place taken by another, so that no time need be lost during the repair of the first shell. (1,035,295, Aug. 13, 1912.)

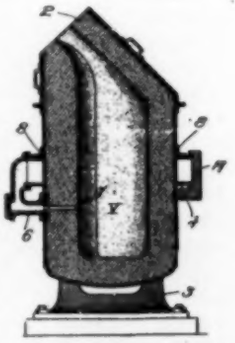


FIG. 5.—IMPROVED CONVERTER CONSTRUCTION.

Gold and Silver.

Electrolytic Amalgamation.—Numerous proposals have been made for the recovery of free gold by amalgamation aided by electrolysis. Two forms of apparatus have been devised namely, the ordinary plate and the mercury riffle or well. For certain reasons the former type has not been successful when the plate is connected as cathode of an electrolytic apparatus, but the latter type has given promise of success. Dr. HENRY NOEL POTTER, of Hollywood, Cal., has devised an interesting apparatus of the riffle or well type, shown in Fig. 6, which may be used either for ordinary amalgamation or in combination with an electric current. The construction of the apparatus embodies several features essential to successful amalgamation.

The apparatus consists of a vertical series of pans 1, which are molded of some insulating composition, preferably Bakelite. Each pan is adapted to hold mercury 3, and there is a passage 4 in free communication with the next lower pan. Above the mercury and so disposed as to provide a definite path for the flowing liquid, is a baffle 8, which also serves as the anode of the apparatus when used electrolytically. The cathode connections to the mercury are made through bars 9.

In operation, the stream of gold-bearing ore flows in a tortuous path through the apparatus from top to bottom, passing

over the baths of mercury and being continuously agitated by the several changes of direction, so as to present new surfaces of ore to the amalgamating bath. The inventor has observed that when a gold-bearing stream flows over a surface of electropositive mercury or amalgam, the extraction seems to be limited to the gold in a thin layer at the bottom of the stream. Hence, the logical manner of improving the extraction lies in periodically mixing the stream and presenting new surfaces to the mercury.

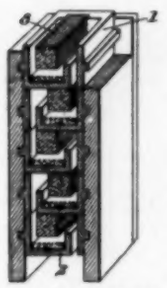


FIG. 6. ELECTROLYTIC AMALGAMATOR

The apparatus may be used without the electric attachments, but where the gold is "rusty," or the mercury tends to become foul, or where native platinum or platinum metals are present, the eletrolytic effects are necessary for best results.

The principle may be applied for the electrolytic decomposition of cyanide solutions of gold and silver. In such a case it would not be necessary to remove suspended solids by filtration. The apparatus may be used also for preliminary treatment of gold-bearing ore to remove the coarse gold by amalgamation and allow the fine metal to be dissolved by a cyanide solution. (1,030,490, June 25, 1912.)

Vacuum Filters.

New adaptations of the principle of the vacuum filter are being proposed by several metallurgists. Recently these are taking the form of groups of filter-leaves mounted vertically about a central shaft and adapted to revolve through a tank of ore-pulp. In our last issue we described one such filter and herewith two more. The first is by Mr. C. K. BARNES, of Pearce, Ariz., and is illustrated in Figs. 7 and 8, the latter showing one of the segmental units of the former. Each segment is a filter on which a cake is formed, washed and discharged during a cycle of operation. By suitable valves and connections, the segment is first acted upon by a vacuum pump and then by compressed air, respectively to form and discharge the cake. The valuable solution is collected through the central shaft.

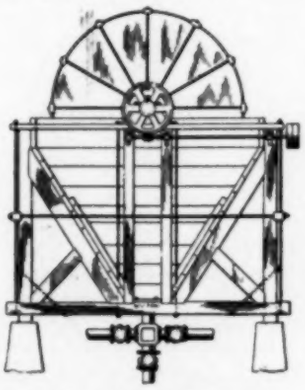


FIG. 7.—VACUUM FILTER.

In operation the tank is first filled with slime and the leaves pass through it and accumulate a cake. The residual slime is then removed from the tank and replaced by wash solution, through which the leaves again pass. After the wash is complete, the tank is again emptied, whereupon the filter-cake is blown off the leaves into the tank and discharged to waste. Each filter segment is formed of a piece of corrugated wood, over which the filtering medium is stretched. (1,036,174, Aug. 20, 1912.)

FIG. 8.—SEGMENT OF FILTER WHEEL.

A similar type of filter is shown in Figs. 9 and 10, being the invention of Mr. ARTHUR A. HOLLAND, of Hastings-upon-Hudson, N. Y. This machine differs from the one just described in several particulars. It has a stationary central tube 11, about which the filter-wheels revolve on a sleeve to which they are attached by spokes. The cycle of filtration consists in the formation, washing and discharge of a cake, with separation of the gold-cyanide solution; but the washing is accomplished by sprays of water issuing from wash boxes disposed between the filter-wheels. These are shown in the broken part at 28, with the spray holes at 18. The discharged cake falls from the leaves into a trough 14

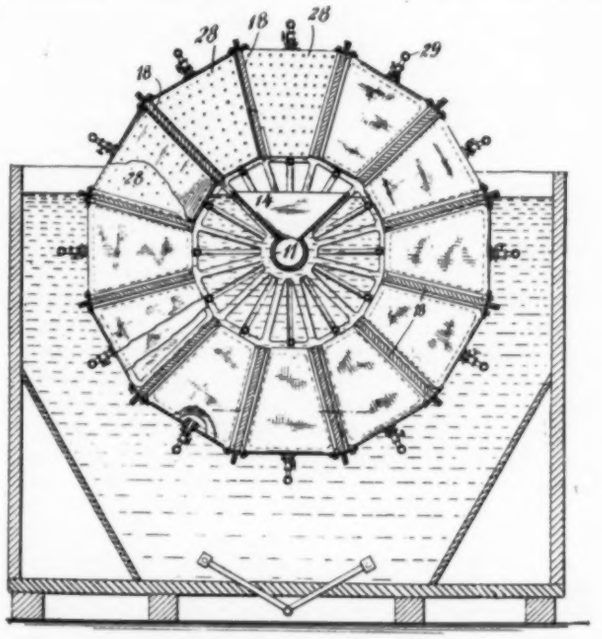


FIG. 9—REVOLVING VACUUM FILTER.

which is attached to the stationary central tube. The accumulated slime is washed out through this central tube. The gold-cyanide solution is drawn off through pipes 29 which are connected with each series of segmental units, and which have

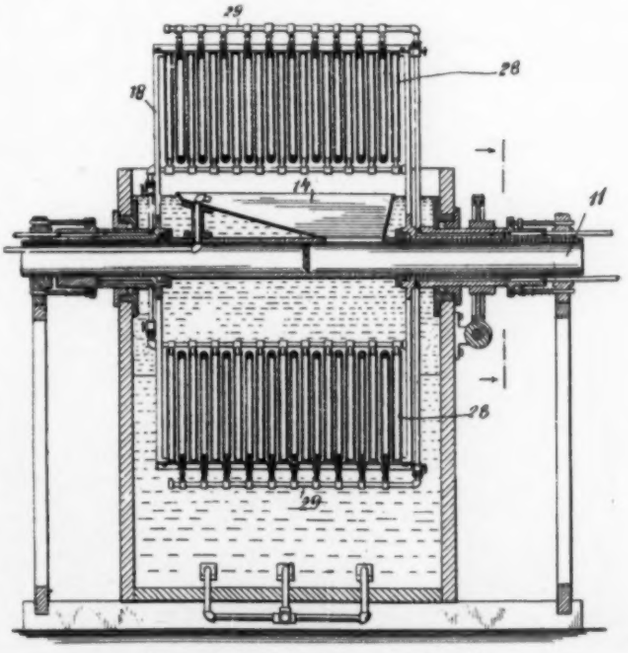


FIG. 10.—REVOLVING VACUUM FILTER.

an outlet through the sleeve about one end of the stationary central tube. Fig. 10 gives a sectional view of the machine. (1,036,847, Aug. 27, 1912.)

Filter Feed.—In Fig. 11 is shown a feed box adapted to deliver slime onto a filter of the type employing a plurality of moving filter pans. It is the invention of Mr. BRUCE W. TRAYLOR, of New York City, and consists of a pipe 2 which deliv-

ers slime into a box 3 which has a series of outlets 3a along each edge. The box is supported as shown at 4. Projections are provided at 5. As the train of pans travels under the feed

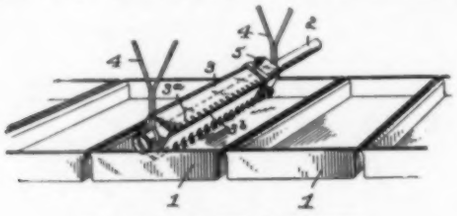


FIG. 11.—FEED FOR PAN FILTER.

box, the pan walls engage the projections 5 and cause the feed box to rotate a quarter-turn, temporarily shutting off the feed so that no slime will be lost, and allowing it to come on again when the next pan is in position. (1,037,561, Sept. 3, 1912.)

Copper.

Combination Smelting Process.—In a patent granted to Mr. Story B. Ladd, of Washington, D. C., he proposes to utilize electric heat to assist in maintaining the proper temperature of the furnace in smelting sulphide ores. The furnace is constructed in the ordinary manner, with the addition of electrodes placed in the hearth. The patentee claims that this method of securing heat will permit the use of only such carbon in the form of coke as may be necessary for chemical action; that the character of the resulting matte will be improved; that it provides a zone of highest heat at the base of the stack below the tuyeres, and that the temperature of the furnace is under more perfect control. (1,035,608, Aug. 13, 1912.)

Separating Solids from Gases.

Electric Precipitation.—It is well known that particles in a gaseous body tend to deposit therefrom when the gas is brought into an electric field between two electrodes of high potential difference. Dr. F. G. Cottrell and Mr. H. A. Burns, the former of Berkeley, and the latter of Oakland, Cal., make use of this principle in a patented process for separating suspended particles from gaseous bodies.

The deposition of such suspended particles is facilitated if the terminals of the electric field, in which the gas is inclosed, are of the nature of sharp points or edges, fine hairs or similar bodies of very small electric discharge surface. Such bodies are used as "discharge" electrodes, in contradistinction to "collecting" electrodes, the latter being relatively large in area and of smooth surface. Suspended particles in gases under treatment tend to deposit mainly on the smooth electrodes.

The selection of suitable "discharge" electrodes has been one difficulty encountered in applying the process on a commercial scale. Further difficulties have been found in suitably arranging and suspending the electrodes in flues or chambers so as to secure rapid precipitation. It is the object of the improvements described here to meet these difficult conditions. Discharge electrodes must resist deteriorating action of the gas and should present the greatest number possible of fine points or edges. Further, the material should be sufficiently non-inflammable and heat resisting so that no damage will be done by occasional arcing. Sheet mica in some form has been found eminently satisfactory for the purpose. In order to provide conductance the mica is clamped between supporting structures which are electrical conductors, and this is done in such a manner that the relatively narrow protruding, serrated edges of mica may be sufficiently charged through surface leakage from the charges imposed on the supporting structure.

Fig. 12 gives a view showing the manner of assembling the discharge and collecting electrodes, with features of support and insulation. This system is called by the inventors the "staggered" arrangement. The collecting electrodes *A* are suspended parallel to the direction of flow of the gas from supports 5. Swinging of the plates is prevented by a guide 6. Where the collecting electrodes are to be grounded, the discharge electrodes must be insulated and maintained at a fixed distance from the opposed collecting electrode. The supports must be provided outside the flue where the insulation can be kept clean and dry. Thus, busbars 8 resting on insulators 9 must pass through sufficiently large holes in the walls of the flue so that there will be no arcing at this point. The discharge electrode *B* is keyed to the top of busbars 12. The latter are, in turn, supported by bars 13 running parallel with the flue walls and held on horizontal bars 8 resting on the insulators 9, which are outside the flue.

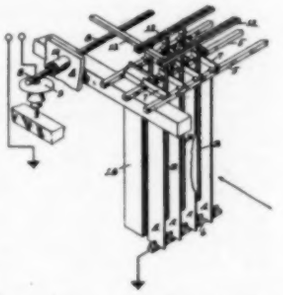


FIG. 12.—ELECTRIC PRECIPITATION OF SUSPENDED PARTICLES.

(1,035,422, Aug. 13, 1912.)

The Vaporization of Metals.*

By Prof. Joseph W. Richards.

Most practical metal workers know that some metals are volatile. No one knows many exact facts about this matter.

Metals have vapor-tension curves similar to that of water. Water at ordinary atmospheric pressure boils at 100 deg. C., or 212 deg. F. But at lower pressures it boils at lower temperatures; at half atmospheric pressure it boils at one-tenth atmospheric pressure at 46 deg. C., and at one-hundredth atmospheric pressure at 7 deg. C.

A point not generally understood is that an indifferent gas in contact with a volatile substance acts like a vacuum as far as inducing evaporation is concerned. Water evaporates in a current of dry air at any temperature whatever; the only condition being that the dry air be renewed as fast as it becomes saturated with the water vapor. Even solid water, ice, will evaporate in a current of dry air, although the temperature remains below the melting point of the ice.

All that has been said of water is true of metals. They all have definite boiling points under atmospheric pressure, lower boiling points at lower pressures, and can evaporate at any temperatures down even to their freezing points, if the pressure is sufficiently reduced. They will also vaporize at low temperatures in the presence of an indifferent gas, if the latter is renewed as fast as it is saturated with the metal vapor.

To illustrate the above principles, let us cite zinc, which boils under atmospheric pressure at 920 deg. C., but which has an appreciable vapor tension at as low a temperature as 289 deg. C. or 130 deg. C. below its melting point. This tells us that not only will zinc evaporate rapidly when melted, in a current of indifferent gas, but that even solid zinc can give off zinc vapor. Similar facts are true, although in a smaller degree, of many metals ordinarily considered as non-volatile. Silver, for instance, can evaporate from solid ingots which are being heated by direct contact with a flame, the gases of the flame carrying away with them more or less silver vapor, just as dry air can carry off water vapor from ice.

Evaporation and volatilization of metals can best be avoided by melting them out of contact with currents of gases; that is, by heating in closed vessels. This can be accomplished either by melting them in crucibles with covers, or by using electric furnace heating. The latter is to be preferred, and will be found much less expensive for power than is commonly supposed. I believe, for instance, that brass can be, at the present time, melted more cheaply in electric furnaces than by fuel, almost anywhere in the United States, with great saving of the zinc usually vaporized.

*Abstract of a paper read at the Allied Foundrymen's Convention in Buffalo, last month.

Synopsis of Chemical and Metallurgical Literature

Heat Transmission of Vacuum Evaporator Tubes.—Prof. H. MCCORMACK has carried out a joint investigation with Messrs H. C. DORMITZER and P. ROLESON on the comparative efficiency of copper, steel, lead, and tin for vacuum evaporator tubes. The tests were made with a Swenson evaporator. The results of the tests are given in form of tables in the July issue of *Chem. Eng.*

The average results of this series of tests may be summed up as follows: Copper tubes, efficiency 83.4 per cent; steel tubes, efficiency 79.5 per cent; tin tubes, efficiency 76.7 per cent, and lead tubes, efficiency 78.8 per cent.

From the above results it may be seen that the efficiency is highest for the copper tubes and next highest for the steel tubes. These results would be expected, inasmuch as copper and steel have a higher coefficient of heat transmission than the other materials used, and also from the fact that the copper and steel tubes were from one-third to one-fourth as thick as the other two sets of tubes. The difference in the efficiency of the copper and of the steel is not as great as might be expected from the difference in their heat conductivities. This is, doubtless, due to the fact that both tubes were very thin.

The relation of the efficiencies of the lead and tin tubes are somewhat harder to explain. Although the coefficient of heat transmission for tin is greater than that of lead, and although the lead tubes were about one-eighth thicker, the efficiency of the latter is greater. It may also be noted in this connection that the exhaust steam came out at a lower temperature in the case of the lead tubes, than of the tin. Unless there is some unknown error in these determinations the authors are unable to account for these facts.

In general it may be said that there is very little difference in the efficiencies for the various tubes, the maximum difference being 6.7 per cent. This is doubtless due to the fact that, with tubes of the small thickness used the coefficient of heat transmission does not materially affect the efficiency. This figure may be altered one way or the other, by changing the velocity of the steam.

Coking of Coal at Low Temperatures.—Bulletin No. 60 of the University of Illinois, Engineering Experiment Station, contains a paper on the coking of coal at low temperatures, with a preliminary study of the by-products, by Prof. **S. W. Parr** and **Dr. H. L. Olin.** The seven chapters deal with introduction, experimental work, gases, tar, coke, the formation of coke, and summary. The conclusions of the authors are as follows:

1. Coals of the Illinois type can be coked at a temperature approximately 400 deg. or 450 deg. C.

2. The gaseous products consist chiefly of illuminants of high candle-power, and represent, together with the condensible material under (3) following, the chief elements involved in formation of smoke in the ordinary combustion of raw coal. The nitrogen of the coal is liberated as NH_3, at these temperatures, in amounts representing approximately 20 per cent of the total nitrogen present.

3. The condensible distillate consists largely of oils with the minimum amount of tar and free carbon. The oils represent positive values for fuel, for carburetting water gas, or for other specific uses, on account of their chemical characteristics as unsaturated compounds.

4. The coke residue has special characteristics which seem to make it of value as a concentrated fuel, capable of combustion without the formation of smoke, suitable for storing without the possibility of spontaneous combustion, and presumably adapted to the manufacture of gas for use in the suction gas producer.

5. Certain facts seem to have been developed concerning the principles involved in the formation of coke which may open the way to the production of a kind of coke of such texture and strength as to make it acceptable for uses that are not now possible with coke made from similar coal, but formed under ordinary conditions, such as are found in the ordinary gas house retort practice, or that of the by-product coke oven.

Other considerations are pertinent in this connection, such as losses and pollution of the atmosphere which accompany the production of smoke.

Further studies have in mind the carrying out of the processes as indicated with apparatus involving the continuous feature, subjecting the mass at the point of greatest fusibility to the pressure of the oncoming material and producing the coke in amount sufficient for testing its properties in the gas producer and for combustion in other ways which would test its properties as a smokeless fuel.

There is an appendix giving a review of the literature on low-temperature distillation including the studies of the by-products, followed by references to the theories concerning coke formation and the carbonization of coal in general.

Alumina as Drying Agent.—In the July issue of the *Journal* of the American Chemical Society appears a note by F. M. G. JOHNSON, of McGill University. The results recorded are so striking that they would seem to suggest technical applications, though this is not mentioned. "In the course of an investigation on phosphonium compounds a drying agent was necessary which would successfully dry both PH_3 and HI or HBr, since P_2O_5 proved useless for this purpose. Satisfactory results were obtained by employing Al_2O_3 prepared by igniting the hydroxide at a low temperature. A test of the efficiency of this substance to take up moisture was made by passing air saturated with water vapor at room temperature, about 18 deg. C., through a tube containing about 7 gr. of the oxide, and then through a second tube filled with P_2O_5. The air was led through at the rate of about two or three bubbles per second. Both tubes were weighed from time to time.

"The somewhat remarkable result obtained was that the P_2O_5 tube showed no perceptible gain until the Al_2O_3 had increased about 18 per cent in weight, corresponding to the formation of the hydrate $Al_2O_3.H_2O$. The reaction is generally represented by the equation $Al_2O_3 . 2AlO(OH)$.

"The formation of the hydrate is accompanied by evolution of heat, hence increased temperature causes its dissociation into Al_2O_3 and H_2O. It is thus seen that 1 gr. of Al_2O_3 can practically completely absorb all moisture from approximately 10 liters of air saturated with water vapor at 18o C.

"G. P. Baxter and R. D. Warren investigated the drying properties of $CaBr_2$, $ZnBr_2$, and $ZnCl_2$, and from their results it is seen that compared with Al_2O_3 these substances are much inferior as desiccating agents. Al_2O_3 is also more effective than H_2SO_4. A tube filled with Al_2O_3 can be used for an indefinite period, if from time to time it is heated with a smoky flame while air, previously led through H_2SO_4, is passed through it. To replace the usual P_2O_5 tube used in connection with mercury pumps it appears particularly suitable, since the tube used need never be renewed. A small tube of P_2O_5 following the Al_2O_3 would serve to indicate when the Al_2O_3 needed reheating. Its uses in many investigations are obvious."

Heating of Nitro-glycerine.—Technical paper 12 of the Bureau of Mines, deals with the behavior of nitro-glycerine when heated, the authors being WALTER O. SNELLING and C. G. STORM. Nitro-glycerine begins to decompose at temperatures as low as 50 deg. or 60 deg. C. At a temperature of 70 deg. C. nitro-glycerine of commercial quality evolves enough nitrous fumes to give a decided test with potassium-iodide-starch paper at the expiration of 15 to 30 minutes. Moreover, nitro-glycerine tends, even at very low temperatures, to be somewhat volatile, and it is well known that even at ordinary room temperatures nitro-glycerine loses slowly in weight through volatilization. At somewhat higher temperatures both the decomposition and the evaporation of nitro-glycerine increase. At a temperature of

about 135 deg. C. the decomposition of nitro-glycerine is so rapid as to cause the liquid to become of a strongly reddish color, owing to the absorption of the nitrous fumes resulting from that which is decomposed; and at a temperature of about 145 deg. C. the evolution of decomposition products is so rapid that, at atmospheric pressures, ebullition begins, and the liquid "boils" strongly. This "boiling" is due in part to the evolution of decomposition products (mainly oxides of nitrogen and water vapor) and in part to the actual volatilization of nitro-glycerine itself.

The decomposition of nitro-glycerine is accompanied by the evolution of much heat, and as soon as ebullition of a sample of nitro-glycerine has begun, enough heat is generated within the liquid to rapidly raise the temperature of the mass, unless some means is provided for conducting away the heat evolved. At temperatures between 145 deg. and 215 deg. C. the ebullition of nitro-glycerine becomes more and more violent; at higher temperatures the amount of heat produced by the decomposing liquid becomes proportionally greater, and at about 218 deg. C. nitro-glycerine explodes.

When nitro-glycerine is maintained at a temperature between 145 deg. and 210 deg. C., its decomposition goes on rapidly, accompanied by much volatilization, and under these conditions nitro-glycerine may be readily distilled. The distillate consists of nitro-glycerine, nitric acid, water, and other decomposition products. The residue that remains after heating nitro-glycerine under such conditions for some time probably consists mainly of glycerine, with small amounts of dinitroglycerine, mononitroglycerine, and other decomposition products. These substances are far less explosive than ordinary nitro-glycerine, and accordingly by heating nitro-glycerine slowly it can be caused to "boil" away until the residue consists of products that are practically nonexplosive. In a number of experiments nitro-glycerine was thus heated, and a copious residue was obtained. By carefully raising the temperature this residue could be made to char without explosion.

Electrolytic Copper in Norway.—According to a note in the *London Electrical Review* of October 4 "the past 12 months has witnessed the erection at Aamdal of the first copper works to produce pure copper on the spot where the ore is mined by M. Hybinette's process of extraction, during which the copper is elutriated from the ore by weak sulphuric acid and precipitated from the solution to pure copper by the help of electricity. The works will probably increase their production in the coming year to 3 tons of metallic copper per diem. The satisfactory results at Aamdal, and experiments with the so-called 'kisafbrand,' or pyrites burnings, from the Orkla Mine —one of the largest Norwegian copper and sulphuric mines— have brought into prominence the possibilities of a new Norwegian industry. Owing to the want of suitable Norwegian copper works, the Orkla and Sulitjelma Mines, in both of which foreign capital is largely interested, have hitherto exported their copper sulphur pyrites to Germany and Helsingborg, respectively, to have the copper extracted there. It now, however, appears likely that the Hybinette companies will receive the necessary support from Norwegian cellulose and other manufacturers interested in the consumption of sulphur to enable them to take over this industry." In his paper on the electrochemical industries of Norway (our vol. IX, p. 544, Oct., 1911), Jos. W. Richards mentioned a copper-nickel refinery depending for its ore supply on a copper-nickel mine. The ore is smelted by semipyritic smelting near the mine and the nickel-copper matte shipped to the refinery, where the nickel and copper are electrically separated by the process of Hybinette. The Hybinette separating process was described in our vol. IV, pp. 33 and 34, 1906.

Light Aluminium Alloys.—A paper by Prof. **Ernest Wilson** read before the British Association, noticed in London *Electrician*, Sept. 13, gives the results of exposure tests of light aluminium alloys. Each alloy was suspended on the roof of King's College, London, in order to investigate the influence of exposure upon electrical conductivity. All the specimens are in the form of wire 0.126 in. (3.2 mm.) diameter, and all the resistances are reduced to 15 deg. C. Alloying commercial aluminium with copper alone has proved unsatisfactory, as a 2.6 per cent copper alloy had completely deteriorated in ten years and increased its electrical resistance 25 per cent.

An increase in the percentage of the iron always found in commercial aluminium, or the addition of nickel or manganese to an alloy containing about 0.09 per cent of copper, has beneficial results both from the standpoint of tensile strength and the power to resist deterioration. For example, specimens containing, respectively, 1.16 per cent iron, 2.25 nickel and 1.78 manganese have only increased their electrical resistance about 9 per cent in eleven years.

"Duralumin" is a copper-manganese alloy of aluminium with the addition of about 0.5 per cent magnesium. A specimen about 80 ft. long has been exposed one year and has increased its electrical resistance 5.15 per cent. It would be interesting to know if this is due to the comparatively large percentage of copper (3.5 to 5.5) which this alloy is stated to contain, or if the percentage of manganese (0.5 to 0.8) is too low. This alloy has attracted attention in that a breaking load as high as 90,000 lb. can be obtained, if desired, according to treatment; but as an electrical conductor it does not compare well, since the specific resistance is about twice as great as that of commercial aluminium. A specimen of high-conductivity copper about 80 ft. long has been exposed for one year, and has increased its electrical resistance 1.2 per cent.

The Laws in Force in Europe Against the Emission of Black Smoke

By John B. C. Kershaw.

The increased attention that is now being given on both sides of the Atlantic to the subject of Smoke Abatement, and the success that has attended the efforts of the Public Health Authorities of many important Cities and Centres of manufacturing industry to improve the purity of the atmosphere, renders a comparison of the Laws which are in force in different countries, against the pollution of the air by black smoke, of especial interest at the present time.

The American Laws against smoke emission vary greatly in the different States and Cities, as the majority of the readers of this journal are no doubt aware.

The same condition of affairs exists to a lesser extent in Europe. In certain cities and districts the laws against smoke are stringent, and are vigorously enforced, while in others, considerably laxity is shown, and proceedings against manufacturers for excessive smoke emission are rarely indulged in, and, when undertaken, are rarely successful.

But, although the laws relating to excessive smoke emission may be extremely faulty, and although there may be also great laxity with regard to their enforcement in many places, those who are engaged in an earnest attempt to improve the atmosphere of the chief centres of population and industry in this and other countries cannot afford to be entirely ignorant of the legal side of smoke abatement. The writer in the present article will therefore bring under review the legal position in regard to smoke abatement in Great Britain, and some details will be given also of the proposed amendment and consolidation of the English Acts relating to smoke abatement. The state of the law in Paris, Germany and Austria will de dealt with finally very briefly.

Great Britain.

The English Law relating to the emission of smoke from chimneys is complicated by the fact that the provisions of the Public Health Act of 1875, which apply throughout England (with the exception of London) are amplified and extended by the local Acts of the larger and more important municipal-

ities. Procedure against offenders may be taken either: 1, under the Common Law; 2, under the Public Health Act of 1875; or 3, under the Smoke Clauses inserted in these various local Public Health Acts.

As the powers conferred by the latter are not uniform, there is considerable force behind the demands now being raised for a revision and consolidation of the laws relating to smoke, and for the passing of an Act which would apply to the whole country. The difficulty in obtaining convictions for the emission of black smoke at present, however, is due to the reluctance of Magistrates and Stipendiaries to enforce very strictly the existing laws, and it is very doubtful whether a greater number of convictions would be obtained under a uniform and more stringent law, applicable to all districts of the country. In the writer's opinion, further education of public and private opinion in the scientific principles of smoke abatement is required before more stringent legislation on the subject can be effective. He believes therefore that the efforts now being made to draft and pass a new Bill, through the present Parliament, will prove abortive.

The emission of smoke is held to be a nuisance under *Common Law* when it can be proved that injury to health, to public or private property, or personal discomfort, has resulted from the same. Although convictions have occasionally been obtained under this law, it is not usually invoked in smoke nuisance procedure, since the clear proof required that the injury is due *alone to smoke*, and also to the smoke emitted by *one particular chimney*, is not easily given.

Clauses 91-98 of the Public Health Act of 1875 contain the statutory law relating to the emission of smoke throughout England, and it is under these clauses, or under similar provisions in the various local acts, that offenders are generally proceeded against when a nuisance has occurred.

Section 91, Sub-sections 7 and 8 of the 1875 Act are the most important, and enact that (7) "Any fireplace or furnace which does not, as far as practicable, consume the smoke arising from the combustible used therein, and which is used for working engines by steam, or in any mill, factory, dyehouse, brewery, bakehouse, or gasworks, or in any manufacturing or trade process whatsoever"; and (8) "any chimney (not being the chimney of a private dwelling-house) sending forth black smoke in such quantity as to be a nuisance shall be deemed to be a nuisance liable to be dealt with summarily in manner provided by this Act. Provided,"

First . . .

Secondly: "That where a person is summoned before any Court in respect of a nuisance arising from a fireplace or furnace which does not consume the smoke arising from the combustible used in such fireplace or furnace, the Court shall hold that no nuisance is created within the meaning of this act, and dismiss the complaint, if it is satisfied that such fireplace or furnace is constructed in such manner as to consume as far as practicable (having regard to the nature of the manufacture or trade) all smoke arising therefrom, and that such fireplace or furnace has been carefully attended to by the person having charge thereof."

The remaining Sections of this Act (92-98) deal with the methods by which the law is to be set in motion, this duty being cast upon the Local Authorities, and if they do not act, upon the Local Government Board. One of the present grievances of Smoke Abatement Reformers in England is that the Local Government Board rarely exercises its authority under this Act, and that it allows certain Local Authorities (notably that of West Ham) to neglect its duties with impunity in this matter of smoke emission. The explanation is that West Ham is the most heavily rated District of London, and that to enforce within this District the Smoke Nuisance Clauses of the Public Health Act of 1875 more strictly would involve driving large numbers of manufacturers away from the District, and increasing the burden of the rates upon those that remained.

The Public Health (London) Act of 1891 applies to the Metropolis within the area covered by the administrative County of London, and contains Clauses (23-24) relating to the emission of Smoke, based on those of the Public Health Act of 1875. Clause 23, Sub-section 2, of the London Act, is, however, more stringent than Clause 91 of the 1875 Act, for it imposes cumulative fines for every successive conviction on any person who "being the owner or occupier of the premises, or being a foreman or other person employed by such owner or occupier, (a) uses any furnace 'employed in trade' which is not constructed so as to consume or burn the smoke arising therefrom, or (b) so negligently uses any such furnace so that the smoke therefrom is not effectually consumed or burnt, or (c) carries on any trade or business which occasions any noxious or offensive effluvia, or otherwise annoys the neighbourhood or inhabitants, without using the best practicable means for preventing or counteracting such effluvia or other annoyance."

Clause 24 of the London Act is similar in scope and application to Sub-section 8 of the 1875 Act, and enacts that—

"Any chimney (not being the chimney of a private dwelling-house (sending forth black smoke in such quantity as to be a nuisance shall be a nuisance liable to be dealt with summarily under this Act."

By a decision of the courts given in 1903, it was held that Club premises in London could not be regarded as a "private dwelling-house," and that the owners of these could be proceeded against under the Act for nuisance arising from the emission of smoke. The most notable decision under this Act, however, has been that delivered by Mr. Curtis Bennett, in the prosecution of the owners of the large electrical generating station, situated in Lots Road, Chelsea, which supplies power for the London underground railways. This station possesses four chimneys, each 19 feet in diameter at the top, and the defence was, that the smoke only appeared "black" on account of its great depth and volume, and that if it had issued from a larger number of chimneys of smaller diameter, it would have escaped the notice of the Smoke Inspector. Mr. Bennett on the ground of this specious defence gave a decision in favor of the defendants, and since that date it has been much more difficult to secure the punishment of offenders, for nuisance arising from smoke, within the metropolitan area. The attempt made by the London County Council in April, 1910, to obtain an amendment of the law by deletion of the word "black" from Clause 24 of the Act of 1891 failed, and the legal position as regards smoke emission within the Metropolis is therefore left in the somewhat unsatisfactory state to which it has been reduced by Mr. Curtis Bennett's decision of 1908.

Local Acts.

The Municipality of Glasgow have been the most active and successful in regard to the subject of smoke abatement. Proceedings for nuisance arising from smoke in that city are taken under Section XXXI of the Glasgow Police Act of 1892, which reads as follows:

"Every person who so uses, causes, permits, or suffers to be used, any furnace or fire within the City (except a household fire) so that smoke issues therefrom, unless he proves that he has used the best practicable means for preventing smoke, and carefully attended to, and managed such furnace or fire as to prevent as far as possible smoke issuing therefrom, shall be liable for the first offence to a penalty not exceeding forty shillings, and for the second or any subsequent offence (if committed within twelve months of the immediately previous conviction) to a penalty not exceeding five pounds."

The Municipality of Glasgow maintains five Smoke Inspectors to enforce the provisions of this Act.

Manchester.

Although Manchester possesses a Local Act of 1844 that contains a clause dealing with smoke emission, proceedings in

that City are always taken under the smoke clauses of the Public Health Act of 1875. The penalty that can be imposed under this Act has, however, been increased to £10, and the aggregate time allowance for black smoke is two minutes in an observation extending over thirty minutes. The City maintains four Smoke Inspectors.

Liverpool.

Proceedings in Liverpool are generally taken under Section 24 of the Sanitary Amendment Act passed in 1854, as amplified by the later extensions (obtained in 1882, 1902 and 1905) bringing within the scope of the Act steamboats plying for hire in the River Mersey, and all furnaces employed for any purpose in the City other than (a) domestic fireplaces, and (b) furnaces employed in working the engines of any vessel not already subject to the provisions of the said Section.

Section 24 of the 1854 Act is worded as follows:

"And whereas it is expedient to make further provisions for the prevention of nuisances arising from the emission of smoke: Be it enacted that all furnaces employed in the working of engines by steam, and all furnaces employed, or to be employed, in any mill, factory, forge, foundry, sugar-refinery, pottery, distillery, chemical works, dyehouse, brewery, bakehouse, gasworks, waterworks, and other buildings used for the purpose of any trade or manufacture whatsoever, within the said borough (whether a steam-engine be used or employed therein or not); and all furnaces employed in working the engines of any steamboat plying on the River Mersey, and of any steam-tug or boat employed for the purpose of towing or hauling any ship or vessel in the said River, or plying for such employment, shall in all cases be constructed or altered so as to consume or burn the smoke arising from such furnace; and if any person shall use any such furnace which shall not be constructed to burn or consume its own smoke, or shall so negligently use any such furnace so that the smoke arising therefrom shall not be effectually consumed or burnt, or so that an unnecessary or excessive quantity of smoke shall be emitted, or shall carry on any trade or business which shall occasion any noxious effluvia or otherwise annoy the neighbourhood or inhabitants, without using the best practicable means for preventing or counteracting such smoke, or other annoyance, every person so offending, and the owner or occupier of the furnace from which such smoke is emitted, or of the place where such trade or business is carried on, and the owner, master, or other person in command or charge of such steam-boat, shall forfeit and pay a sum of not more than £5 for and in respect of every day during which, or any part of which, such furnace or annoyance shall be so used or continued. Provided always that the words 'consume or burn the smoke' shall not be held in all cases to mean 'consume or burn all the smoke,' and the Justice before whom any person shall be summoned may remit the penalties enacted by this Act if he, or they, shall be of opinion that such person has so constructed or altered his furnace as to consume or burn, as far as possible, all the smoke arising from such furnace, and has carefully attended to the same, and consumed or burned as far as possible the smoke arising from such furnace. Provided also, that no proceedings shall be taken under the above Section except by some Officer of the Council, duly authorized by the Health Committee in that behalf.

The latter part of this Clause considerably weakens the first portion, and leaves rather too much latitude in the hands of the Justices. Liverpool maintains three Smoke Inspectors.

Proposed Amendment of the Law.

The main provisions of the general and local acts relating to Smoke Abatement in Great Britain have been dealt with briefly in the preceding portion of this article. It will now be useful to glance at the main provisions of the Amended Act which is being prepared for presentation to Parliament this year by those who desire to see the existing powers of the Local Authorities in relation to this subject strengthened and made more uniform. The chief objects of those who are promoting this measure are: (1) to obtain one uniform law for the whole country, thus avoiding the difficulty that now confronts the local authority of West Ham; (2) to remove the Smoke Inspectors and others who have to administer the Act from complete dependence upon the local authority for their position, influence and income; (3) to increase the minimum fine for offences under the Act, and to make such fines cumulative in effect for repeated offences.

Local Smoke Prevention Authorities would be constituted by order of the Local Government Board to enforce the provision of the Act, and these bodies would appoint Local Smoke Inspectors who would be paid, as to one-half of their salary by the Local Authority, and as to the other half by the Local Government Board. Government Smoke Inspectors would be appointed also by the latter, each to have charge of certain districts (as under the Alkali Acts), in order to ensure that no Local Authority was neglecting its duties in relation to the proper enforcement of the Act.

That an Amended Act on these lines will be passed for England sooner or later the writer fully believes; the experience gained under the Alkali Acts showing the value of properly trained and qualified Inspectors in aiding the manufacturers to conduct their works without the creation of any nuisance. It may be doubted, however, whether public opinion is yet sufficiently educated to supply the force necessary for driving a Smoke Abatement Act through Parliament; and if it were, the present British Government has its time too fully mortgaged to allow it to take up a measure of this kind unless assured that it would be treated as a non-controversial Bill.

France.

There is no legislative enactment in France for the prevention of the emission of smoke from factories or business premises, but a series of ordinances have been published in Paris by M. Lepine, the energetic Chief of the Police. This City, which is generally regarded as the cleanest city in Europe, is under a law which is much more lax than that enforced in London.

The prefect of police published an ordinance on the 22nd of June, 1898, prohibiting the prolonged emission of thick black smoke from industrial establishments. Six months were allowed to manufacturers to carry out the necessary improvements, but the prefect of police has refrained from a rigorous application of the regulations owing to the impossibility of finding an absolutely perfect apparatus for consuming smoke. Choice of fuel, care in stoking furnaces, and well-constructed chimneys may contribute largely to the restriction of smoke, but cannot entirely prevent its emission.

After stoking furnaces every morning, and after each successive stoking during the course of the day, the Inspector allows an emission of smoke three times as long as that allowed in London, under the law of the 5th August, 1891. Great difficulties were met with by the Paris Municipality in carrying out the regulations, owing to the bad examples set by many public buildings, the managers of these refusing to comply with the provisions of the Decree of 1898.

The cleanness of Parisian buildings and clearness of Parisian skies is therefore more due to the absence of the open fireplace from the domestic hearth than to the strictness of the laws against the emission of black smoke.

Germany.

Mr. Arnold Robertson, Third Secretary of the Embassy at Berlin, states in his Report that there are no actual laws in force in Germany for the restriction of the emission of smoke from factories, business premises, and private dwelling-houses. Although no laws are in force, however, great attention has been given to the subject by the State Authorities, and a commission was appointed a few years ago to examine and report upon the means generally adopted for smoke prevention or

consumption. As a result of the labors of this commission, a circular letter was sent by the Prussian Department for Trade and Industry to the various local authorities, requesting them to see that the measures recommended by the commissioners were adopted in all works and factories belonging to the State, or under State control. For guidance in this matter the Department also published a leaflet of instructions to the local authorities, embodying the more practical portion of the principles and teachings of the commissioners. The educational value of the examples set by the factories and works owned by the State Authorities was therefore expected to minimize the smoke evil in Germany.

Austria.

Many complaints have recently been made in Austria with regard to the emission of thick black smoke from factories and furnaces in the various parts of the country. This has been specially the case in industrial centres, where there is great consumption of coal and other kinds of fuel, and in the various health resorts and watering places, where it is of special importance that the air should be kept pure and uncontaminated by smoke. This problem also presents itself in the case of railways, where the interests of the travelers and those of residents in the neighborhood of stations come into consideration. That no legislative measures exist at present to obviate this nuisance may be attributed to the following causes:

In the first place it must be emphasized that the compulsory introduction of technical measures to procure smokeless or almost smokeless fires would only be practicable if thoroughly adequate appliances existed to ensure the desired result. In this connection experience shows that no system hitherto recommended and applied is exempt from serious disadvantages. The best laid furnace requires constant supervision and attention, nor will it burn properly unless carefully tended. *There is a well-known saying to the effect that a good stoker is the best consumer of smoke.* It must also be taken into consideration that manufacturers oppose a justifiable resistance to the introduction of more or less expensive apparatus for the prevention of smoke, on the ground that the saving of fuel alleged by the inventors does not in reality take place.

In spite of these various difficulties, the problem of finding the best means of combating the smoke nuisance has never been lost sight of in Austria, and it is at the present moment forming the subject of negotiations between the competent Government Departments.

The above extracts are taken from a Government Report relating to the *"Laws in force in certain Foreign Countries in regard to the Emission of Smoke from Chimneys,"* published by the British Foreign Office, in February, 1905.

They indicate that on the Continent of Europe the authorities believe more in educational than repressive measures for dealing with the smoke nuisance, and emphasize the author's view that the best work at present is the education of factory owners, boiler engineers and firemen in the scientific principles underlying the combustion of fuel in the furnaces of heating apparatus generally, and more especially in the furnaces of steam-boilers.

London.

Jigging Unsized Ores.

BY EDWARD T. WRIGHT.[1]

Advance in Present-Day Milling Methods.

Under the sizing system of concentration, classification is the bugbear of the mill designer and operator. No part of the mill presents so much detail, all preliminary to the actual work of separating mineral from gangue. The preliminary separation has been elaborated until many of our mills are very complicated, even bewildering. The proper sizes must be determined, and a selection made of the kind of screens to be used; the merits of trommels, impact or vibratory screens, etc., must be considered to suit the service and ore in hand. Sizes such as the following: 1½ in., ⅞ in., ⅜ in., 3/16 in., 3/32 in., and 2½ mm. may be made with screens; then for the finer sizes we have to select hydraulic classifiers with their four to eight classifications, and with their large consumption of water.

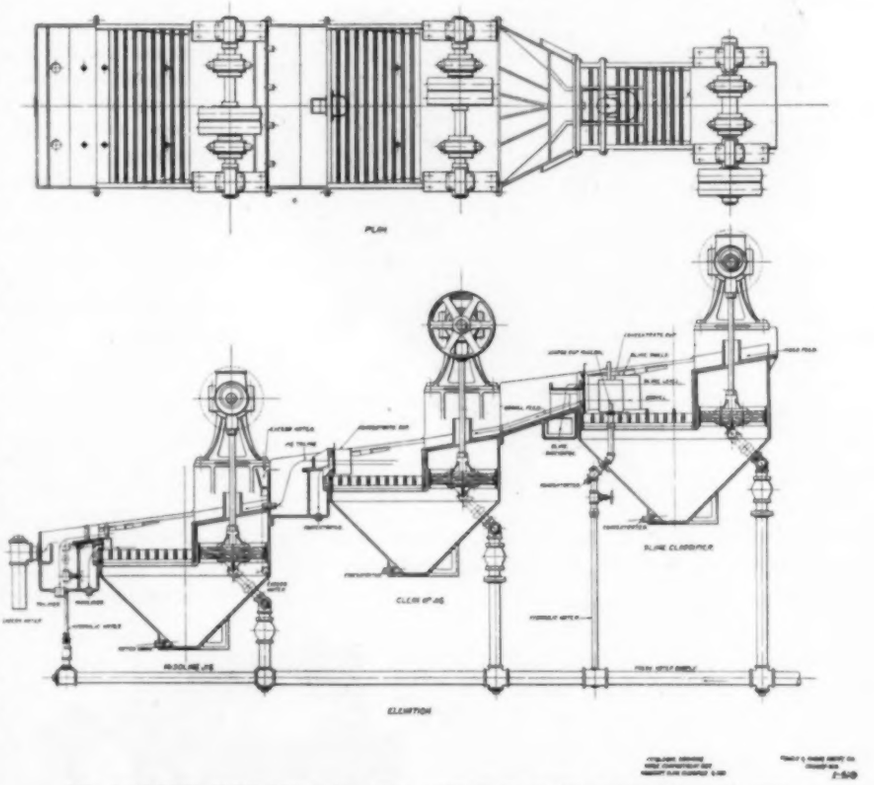


FIG. 1.—THREE COMPARTMENTS UNIT, WOODBURY SLIME CLASSIFIER AND JIGS.

Why all this detail? We understand it is to prepare the ore for the concentrating machines—jigs and tables; that in order to do perfect work these machines must treat nicely sized feeds. Has it ever occurred to us that this preliminary separation may be a result and outgrowth of faulty final separators? That it may not increase our final recovery, but actually lessen it by seriously diluting the ultimate slimes? The hydraulic classifier in making a separation of slime from sand causes a dilution of slime of from 50 per cent to 100 per cent, it being necessary as a result of this dilution to provide elaborate settling systems with resulting overflow losses in fine mineral in order to obtain a slime of proper density for treatment on tables or vanners.

The purpose of this article is to point out to the users of milling machinery a means of simplifying and modernizing the mill, not however, at the expense of recovery of mineral, but actually with largely increased recovery.

Jigs of the Harz type, while they are the oldest of successful

[1]Ore Milling Engineer, Chicago, Illinois.

appliances for jigging ores, do indifferent work on mixed or unsized feeds, and the sizing system has been built up around and to conform with them. We will consider, therefore, a means whereby the complications of the sizing or preliminary

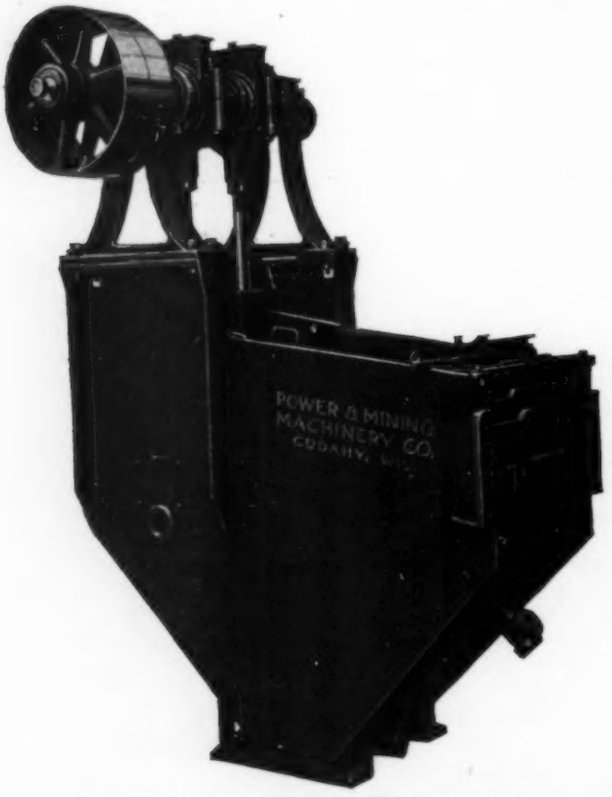


FIG. 2.—SLIME CLASSIFIER, CAPACITY 250 TONS.

treatment can be almost entirely eliminated, while at the same time the slimes are separatd with little or no dilution.

The Ideal Concentrator.

An ideal concentration would be one that would effect a perfect separation of all free mineral and middling from an absolutely mixed or unsized feed, including gravel, sand and slime. As a matter of fact, an unsized feed when passing over a suitable jigging apparatus separates naturally into two fundamental classes: First, slime, i.e., suspended matter or material which will not settle and which floats along over the jig; second, gravel and sand, i.e., material which will settle. Therefore, in bringing out ideal concentrator down to a practical basis, we must provide a device for separating the suspended matter or slime as an unfinished product for subsequent treatment; at the same time, the apparatus must be capable of stratifying and separating from a mixed feed the free mineral and middling from the gangue.

The Woodbury Slime Classifying Jig.

Such an apparatus has actually been brought out, and is being manufactured by the Power & Mining Machinery Company, of Cudahy, Wis., viz., the Woodbury Slime Classifying Jig.

This machine is a development of careful experimental work, and is in practical use at the great Calumet & Hecla mills at Lake Linden, Michigan, and other large plants throughout the world.

It is a refinement of former types of plunger jigs, so arranged that the feed flowing onto the jigs parallels the currents of water, caused by the plunger impulse, enabling the jig to rapidly stratify the sands and gravel in an absolutely mixed feed. An unsized ore (not coarser than minus 3/8-in. round) is delivered at the head of the unit to the first compartment—the slime classifying jig.

This compartment is a jig of the plunger type 24 in. wide. The feed flowing over the sieve quickly separates into its two fundamental classes, viz., suspended matter or slime, and sand and gravel which settles and is stratified. The latter is thoroughly scrubbed free of slime, which is held in suspension by the hutch water, introduced under the plunger.

Slime Discharge.

A device for skimming off the slime in suspension delivers a dense original slime from this compartment as a product for further treatment on suitable tables. This separation is positive and complete, the gravel and sand on the sieve acting as a sand filter and being itself discharged thoroughly freed of all slime. At the same time this classifying jig performs all the regular functions of a jig, and separates a large tonnage of clean cup and hutch mineral, usually from 50 per cent to 60 per cent of all free mineral being separated on this slime classifying jig.

The second compartment, which follows the jig described above, is a clean-up jig for completing the separation of free mineral. This jig is 48 in. wide and usually discharges two finished products, viz., cup and hutch concentrates. The tailings from jig No. 2 pass to jigs No. 3 and No. 4 which are termed middling jigs, and are provided with suitable middling discharges.

Hydraulic Middling Discharge.

These middling jigs are equipped with a very efficient device for discharging middling from an unsized feed, viz., the hydraulic middling discharge. An angle-iron shield is fastened across the tail of the jig, extending down into the middling stratum which seals it against the entrance of tailing. From under this shield a number of openings placed at intervals of 6 in. lead into a hydraulic chamber. A fresh water supply therein, under valve control, regulates the quantity and quality of middling discharged from under shield through these open-

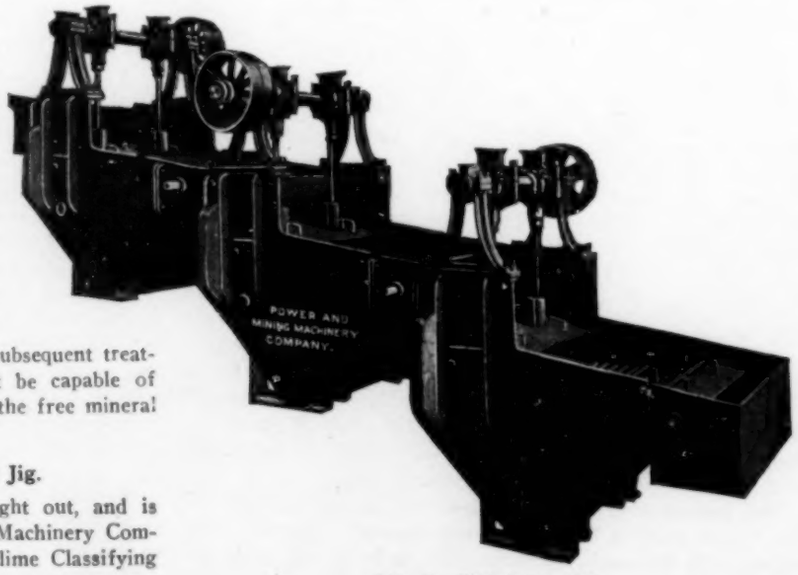


FIG. 3.—WOODBURY JIGS.

ings into the hydraulic compartment and out through plugs in the bottom. The advantages of this device are (1) a uniform discharge over entire width of jig; (2) the separating and discharging of a true middling as stratified on the jig, the hy-

draulic water controlling same and holding back any light tailing material.

Water-Saving Device.

An important feature of these jigs is the water lessener, a device for diverting the excess water in the feed into the hutch of the next succeeding jig. The tailing from one jig passes over the angle-iron shield and hydraulic compartment to the water lessener box of the next succeeding jig, from which it is discharged through plugs over plunger compartment and becomes the feed for the next compartment. The surplus water which cannot discharge through the plugs flows over the top of lessener into a trough communicating with the hutch under the plunger, thus effecting a very material saving in hutch water as well as reducing the quantity of top water which otherwise accumulates and tends to carry off the light mineral.

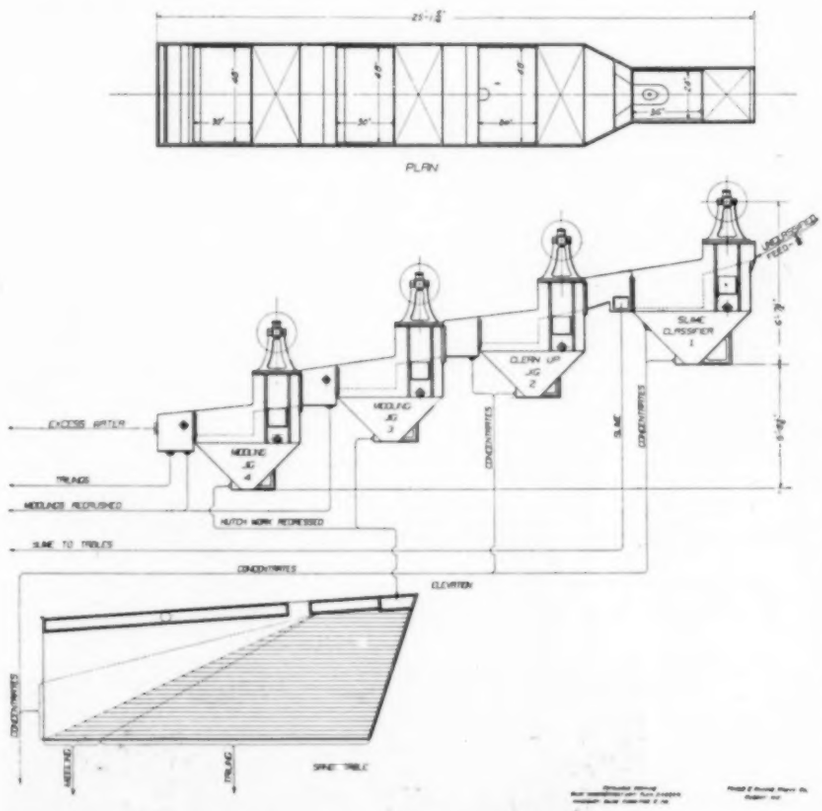


FIG. 5.—APPLICATION OF WOODBURY SYSTEM TO FINE CONCENTRATION.

Hutch Work.

The material discharged from the hutches of jig compartments Nos. 1 and 2 is usually clean mineral, and is included in the general concentrate. From the hutches of the middling jigs is obtained an enriched sand containing any light fine mineral which may have been carried over from the second compartment, this sand usually being redressed on a table of the Wilfley type. From the end of the last compartment a tailing is discharged to waste, the same having been freed, as above described, of slime, free mineral, middling and table sand.

To summarize, therefore, we have a means of handling a mixed feed without preliminary sizing, in large unit tonnages, which will classify same into the desired products:

(1) Slime (approximately 60 mesh and finer), for subsequent treatment on tables.
(2) Concentrates.
(3) Middlings, for regrinding.
(4) Hutch sands, for further table treatment.
(5) Tailings to waste.

General Application.

The writer has applied this mixed feed system, as heretofore described, to various kinds of jigging ores, including native and sulphide copper, lead, zinc, tin, iron and sapphires, and has thoroughly demonstrated its practicability and superiority in coarse, medium and fine jigging. Any ore amenable to wet concentration can be handled to advantage with this system. In ores other than native copper, the mineral is usually softer and more friable than the gangue, and in the process of crushing is more easily slimed. It is therefore advisable to begin concentration as early in the process as possible, in order to recover the valuable mineral as soon as liberated and before it is slimed by further crushing. The proper limiting size at which concentration should begin varies materially on different ores, in some the mineral being liberated during coarse crushing, while in others it is so finely disseminated as to need pulverizing.

Inasmuch as the Woodbury machines will treat unsized ores, preliminary sizing is unnecessary, except where material coarser than ⅜ in. is to be concentrated, when a screen separation is necessary at ⅜ in., the oversize being treated on coarse jigs and the undersize on the classifier jigs. The material coarser than ⅜ in. is treated without further sizing on special jigs, having adjustments and discharges suited to coarse material. When the maximum size of the ore is not over ¾ in., the 48-in. Woodbury oversize jig is used; on a larger maximum size the 60-in. Woodbury bull jig. The undersize of ⅜-in. screens is treated without further sizing on the classifier and jigs.

Roughing Free Mineral and Slime from a Mixed Feed, No Tailing Discarded

Where it is desired to rough out the free mineral before grinding, nothing approaches the simplicity of this arrangement, as the ore from the crushers has simply to be screened at ⅜-in., the coarse mineral in the oversize being separated on an oversize or bull jig, and the free mineral and slime in the undersize being separated on the two-compartment classifier jigs. The rich original slime is gotten out of the system without undue dilution and is passed on to the slime department. The tailing from the roughing jig is recrushed, the coarse jig tailing being crushed to ⅜ in., while the classifier jig tailing is finely pulverized and retreated. In case the mineral is not freed by coarse crushing in sufficient quantity for jigging, the coarse jigs are omitted and the classifier jigs only used as roughing machines.

Ores such as brown and red hematite, coal, pyrite, chalcocite, and chalcopyrite can be roughed in immense tonnages and with great economy in floor space, water, attendance, etc. The unfinished products, slime and middling, are in far better condition than under the sizing system, the slime being dense, not coarser than 60-mesh, and separated at the head of the mill. The middling is a thoroughly classified included product, being cleaned of free mineral which otherwise would be slimed in the regrinding.

Finishing Jigs for Medium Ores, Tailing Being Discarded.

The Woodbury slime classifier and clean-up jig (two compartments only) is required to clean the free mineral and slime from an unsized feed. When it is desired, however, to finish the operation by separating the middling material for regrind-

ing, two middling jigs are usually added to the unit, making the standard finishing unit four compartments in all.

A finishing unit of jigs will handle approximately 250 tons per 24 hours, and as heretofore described, separates the following products: slime, concentrate, middling, table sand and tailing. The feed is unsized and may be the undersize of any size screen not to exceed ⅜ in. round.

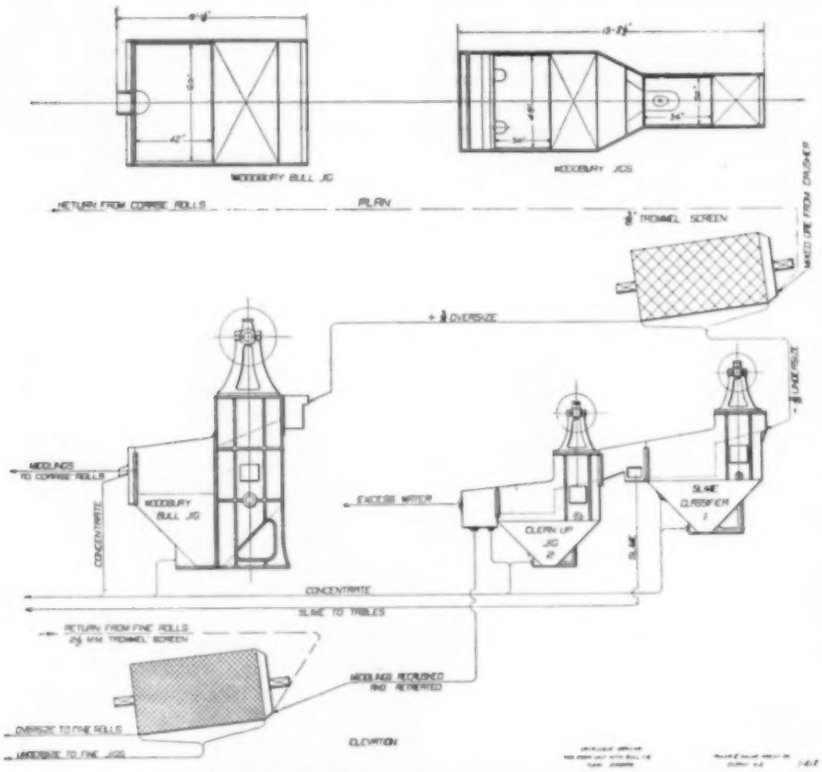


FIG. 4.—SHOWING APPLICATION TO COARSE CONCENTRATION.

The advantages of the system on finishing work are very marked; a dense slime, clean concentrate and well-classified middling being separated with lowered tailing loss. Considerable economy is effected in water, floor space and attendance, and the mill greatly simplified. It should be noted that hydraulic classification and fine screening are entirely eliminated in this system.

Complex Ores.

Where it is necessary to separate two minerals of different specific gravity, a unit of five or even six compartments is required. The slime is separated as above on the first compartment, the heavier mineral on compartments Nos. 1 and 2, the lighter mineral on Nos. 3 and 4, and middling on Nos. 5 and 6, a tailing being discharged from the end of the unit.

The "luminator" purification treatment of water for steam boilers consists in passing the water through an aluminum trough or launder, exposed to sunlight, whereby the deposition of hard scale in the boilers is avoided. The theory of its operation is thought to be electrical, as suggested by several contributors to the *Journal* of the Chem. Met. & Min. Soc., of S. Africa. A galvanometer connected to an aluminum plate over which water was flowing, and to an iron tank in which the water was received, showed a deflection equivalent to from 1 to 4 milli-volts. An explanation of the result is that the aluminum is changed into aluminum hydroxide, which, in an alkaline water, might pass into solution as an aluminate and precipitate salts of calcium and magnesium.

Steam Trap System.

At the saltpetre works of Battelle & Renwick, Jersey City, N. J., a novel steam trap system has recently been started up, which takes care of all the condensation from all the apparatus throughout the mill and returns the same to the boilers. This system not only takes care of all the condensation, but it is so arranged that the waste vapor from the vents of the traps is condensed and returned with the regular condensation.

The mill apparatus consists of nineteen special kettles for boiling. Each kettle is equipped with what is known as a pit coil, that is, the drip from the coil instead of passing through the bottom of the kettle is carried up over the edge, so that the water of condensation is raised 6 ft. before it is discharged. There is also a dry room and drying machines included in the system. The approximate amount of steam required for boiling alone is about 600 hp. The boiling point of some of the liquids in the kettles is as high as 270 deg. Therefore, live steam is required for this work.

On account of the nature of the coils it has been impossible to use ordinary traps on this work, but each coil at the present time is equipped with a special No. 20 Lytton trap which discharges into the return main, of which two are used, running through the factory and back to a receiving tank in the boiler room. The temperature of this return water varies from 260 to 282 deg.

All the vapor from these special traps is used for drying purposes and when condensed is also returned to the boilers, so that no steam or vapor is allowed to blow into the atmosphere.

On the boilers are located two 4-in. return traps and one 1½-in. return trap, which take care of the return water from the factory at the temperatures mentioned and return it automatically to the boilers.

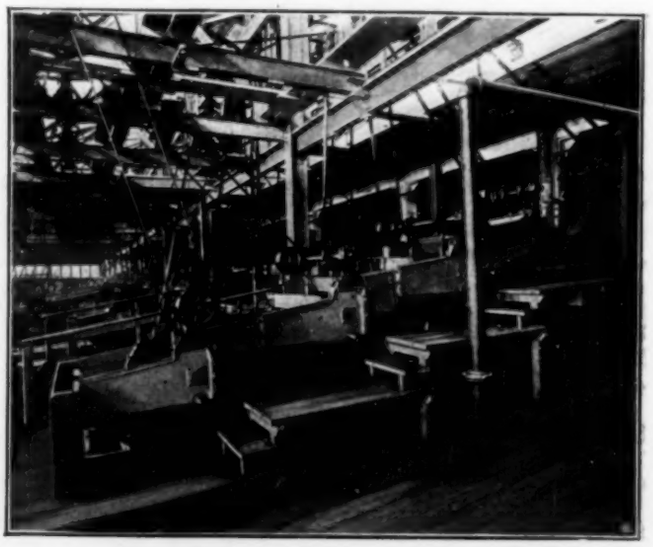


FIG. 6.—WOODBURY SYSTEM APPLIED TO "COARSE" ORES, 500-TON UNIT.

The condensation from the live steam mains is also trapped and collected in a separate return which discharges into the receiver in the boiler room.

By the installation of this system the saving in coal alone amounts to 2½ tons per day, while the boiling capacity of quite a number of the kettles is increased from 15 to 25 per cent.

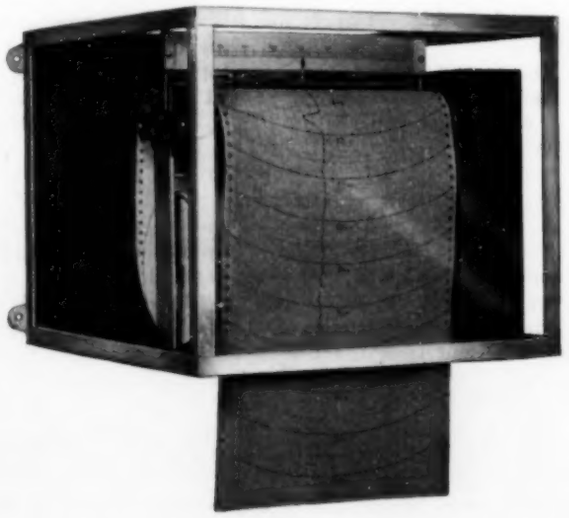
It has not only made quite a saving in coal and increased capacity of the kettles, but it is feeding the boilers with about 90 per cent of pure water, which prevents the formation of scale and also makes an additional saving in the amount of extra water that would have to be purchased from the city.

This system was devised by Mr. D. J. Lewis, Jr., sales manager and trap expert of the Lytton Manufacturing Corporation, and consists of twenty-six Lytton traps, three of which are return traps and the balance regular and special 20 series traps.

Continuous Chart Recording Pyrometer.

The Brown Instrument Company, of Philadelphia, and its associate company, the Keystone Electrical Instrument Company, have brought out a new continuous chart recording instrument, particularly designed for use as a pyrometer, but which can also be used for indicating volts, amperes, revolutions per minute, mechanical operations, etc., where a small current of electricity is required to operate a recording instrument.

This new instrument is of the frictionless type, the pen making a single dot of ink momentarily on the paper at short intervals, every 10 seconds, or every minute as desired, and



CONTINUOUS CHART RECORDING PYROMETER.

these dots practically form a continuous line. The instrument carries a 6 months roll of recording paper, traveling a little over an inch an hour which does away with the necessity of changing the charts daily, and for many operations the continuous chart is preferable. The record can either be torn off as desired every day or once a week, or it can be allowed to roll up continuously.

This new instrument as shown in the adjoining illustration is handsome, simple and practical.

American Vanadium Facts for October, issued by the American Vanadium Company, of Pittsburgh, Pa., contains some very interesting notes on vanadium steel in the machine shop, on vanadium rock drill steel, on a remarkable test of chrome-vanadium steel tire, and on the use of vanadium steel in automobile construction for springs and gears.

A New British Electric Steel Plant.

As a result of some two years' experience in electric steel melting furnaces the Stobie Steel Company of Sheffield, England, is building a new steel works in which all the melting and further treatment of the steel will be electrical. This will be the first big steel works in Great Britain solely engaged on the electrical manufacture of tool steels, alloy steels, and similar material.

The new works are being erected on the Tyne side as current can be obtained on the North East Coast under more favorable conditions than in Sheffield.

The installations will, at first, consist of a 15-ton, three-phase steel melting furnace, a 5-ton, two-phase one for special steels, and a 3-cwt alloy melting furnace. All these furnaces are designed and built by Mr. Victor Stobie who has made a special study of electric steel furnaces from the metallurgical point of view while maintaining all electrical requirements and improvements which help to make the furnace a good load for the power station.

A 2-ton Stobie electric steel melting furnace is shortly being built for another Sheffield steel works and a 15-ton furnace is also projected for a steel works in the north.

Bureau of Standards Analyzed Samples

The Bureau of Standards, Washington, D. C., is now prepared to issue pure sodium oxalate for use as a standard in oxidimetry, in bottles containing 120 and 200 grams, the fees for which are respectively $2.00 and $3.00. With each sample is furnished a certificate giving the purity of the material and brief directions for its use in the standardization of permanganate solutions.

Circular No. 40, "Sodium Oxalate as a Standard in Volumetric Analysis," is now ready for distribution and will be sent upon request. It includes a description of properties, preparation and testing of sodium oxalate, and a discussion of its suitability as a standard in oxidimetry and acidimetry.

The fourth edition of Circular 25, "Standard Analyzed Samples—General Information," is now ready for distribution. Attention is called to the fact that the fee for sample No. 24, Vanadium Steel, has been changed from $2.00 to $2.50.

Chrome-tungsten Steel, No. 31, is now ready for distribution.

Another Cement Mill for California

The Old Mission Portland Cement Company announces that their mill at San Juan, San Benito County, Cal. (formerly the San Juan Portland Cement Company) is to be completed and put in operation in the near future.

The firm of Smith, Emery & Company, Industrial Engineers, at San Francisco and Los Angeles, have been engaged to design and erect the mill.

It is expected that the output of this mill will be a factor in the market next Spring.

Electric Equipment of the New Aluminium Works in North Carolina.

Seven vertical waterwheel type electric generators, which represent units of the largest rating ever built for generating direct current, will be installed in the new plant of the Southern Aluminium Company at Whitney, N. C. Each machine will have a rating of 5000 kw, delivering 20,000 amp at 250 volts and operating at a speed of 170 r.p.m. Two smaller direct-current generators of the same type, rated at 2500 kw at 300 r.p.m.; two 1250-kva alternators, having a speed of 514 r.p.m., with two 16-kw exciters, and all necessary switchboard and controlling

devices are also included in the installation, which will be one of the largest and most modern of its kind in the world. It is the intention of the Southern Aluminium Company to push to completion the project now under way and to have in operation in the course of the next eight months a manufacturing plant that will turn out some 25,000 tons of aluminium annually.

The company was recently incorporated under the laws of the State of New York with a capitalization of $8,000,000 and was organized by some of the largest aluminium manufacturing companies of Europe. The enterprise has been financed in France and is closely associated with l'Aluminium Français, of Paris. The work at Whitney is in charge of Dr. Paul Heroult. Although he has been directing constructive operations there only a few weeks, remarkable progress has been made, and it is confidently expected that the entire plant will be in readiness for turning out the product of the company by the middle of 1914.

In the complement of buildings are nine furnace rooms, wherein the alumina will undergo the various processes incidental to conversion into aluminium. Each of these structures measures 60 ft. by 500 ft., and one electrode factory of similar dimensions is also included in the group.

The generators will be installed immediately over wheel pits and directly connected to vertical shafts of S. Morgan Smith turbines by forged steel flanged couplings. Each 5000-kw generator will weigh in the neighborhood of 150 tons, measure 22 ft. in diameter and extend 13 ft. above the floor level. The entire rotating element of the generators will be supported from an overhead thrust bearing. While the normal speed will be 170 r.p.m., they will be designed with provision for a safety runaway speed of 75 per cent above normal. The wheel governors will be provided with remote electric control for both hand and automatic operation. The electrical equipment will be supplied by the General Electric Company.

Personal.

Mr. **T. M. Caven,** designer of electric heating appliances, has resigned as manager of the Bon Ami Electric Company, Milwaukee, to become manager of the electrical department of the Kieselguhr Company of America, with office at 1633 Monadnock Building, Chicago. Kieselguhr is a natural mineral product, consisting mainly of silica, and is used for a variety of purposes, including heat and electrical insulation. Mr. Caven is interested in pointing out the possibilities of kieselguhr in electric furnace and electric oven work.

Mr. **C. A. H. de Saulles,** son of Major de Saulles, of the New Jersey Zinc Company, has taken a position as manager of the zinc interests of the American Smelting & Refining Company, with headquarters at 165 Broadway, New York City. Mr. de Saulles was brought up in the zinc business and was general manager of the Prime Western Spelter Company (the New Jersey Zinc Company's Western concern). Fifteen years ago he was famous as Yale quarter-back and made the de Saulles runs against Harvard and Princeton.

Mr. **Otto Frick,** the inventor of the Frick induction furnace, has arrived in this country for the purpose of introducing the latest types of induction furnaces for the iron and steel industry, which are handled by Dr. Karl Georg Frank, of New York City, representing the Siemens & Halske Company, of Germany. The furnaces to be installed in the United States will be made in this country.

Mr. **L. E. Ives** has resigned as associate editor of the *Engineering and Mining Journal,* and will hereafter be on the editorial staff of the *Iron Trade Review* as mining and assistant engineering editor.

Messrs. **Joseph A. Richards, Lucius I. Wightman and Paul Morse Richards** announce the formationn of the firm of Wightman & Richards, counsellors and consulting engineers in technical advertising and marketing, with offices at 29 Broadway, New York City. Mr. Joseph A. Richards is the head of the general advertising agency having his name. Mr. Wightman, a graduate of the University of Colorado, has held during the past twelve years various engineering and business positions and has been quite active as a technical writer and author.

Dr. **Wilhelm Schumacher,** of Berlin, the well-known expert on the briquetting of flue dust and iron ores, has arrived in this country on an inspection trip in the interests of the General Briquetting Company, who represent the Schumacher process in the United States. Dr. Schumacher is now in Buffalo looking over his process, which has recently been installed at the works of the Lackawanna Steel Company.

Professor **Clarence P. Linville,** after a service of nine years in charge of the department of metallurgical engineering and as professor of metallurgy at the Pennsylvania State College, has resigned to accept the position of superintendent of blast furnaces with Joseph E. Thropp, and is now located at Earlston (Everett Post Office), Bedford County, Pennsylvania.

Sir William Ramsay, K. C. B., of London, is delivering a series of three lectures on the gases of the atmosphere before the Department of Chemistry of the Polytechnic Institute of Brooklyn, N. Y. All three lectures are held Tuesday evenings at 8:15. The first lectures were delivered on October 22 on the ancient history of the gases of the atmosphere, and on October 29 on the discovery of argon, helium, neon, krypton and xenon. The last lecture will be held on November 5 on niton, or the radium emanation.

Mr. **Kilburn D. Clark,** formerly representative of the Harbison-Walker Refractories Company in New York State and Canada, has secured the representation in the same district for the General Refractories Company, manufacturers of the highest grade fire brick, silica, magnesia and chrome brick, fire clay, silica cement, and importers of magnesite and chrome ore; also the Brighton Fire Brick Company, manufacturers of several grades of fire brick. The main office will be 75 Erie County Bank Building, Buffalo, N. Y.

Obituary.

Mr. **William Horace Corbin,** vice-president of the Joseph Dixon Crucible Company, died on September 25.

Mr. **Frederick J. Mayer,** the highly distinguished gas engineer, former chief engineer of the Bartlett & Hayward Company, and later founder and general manager of the Didier-March Company, died at the age of 59 years.

Dr. **William S. Weedon,** research chemist with the E. I. du Pont de Nemours Powder Company, and formerly with the General Electric Company, died on July 10 at the age of 35 years.

Mr. **Maunsel White,** one of the inventors of the Taylor-White process for the heat treatment of tool steels, died in New Orleans, La., on October 22.

Notes.

The **Electric Furnace Company,** of Alliance, Ohio, designers and builders of the Baily electric furnace for heating bars, billets and ingots, have opened an office in the Oliver Building in Pittsburgh, in charge of Mr. F. M. Rush, and an office in Cleveland, in charge of Mr. F. B. Allen.

The **Primos Chemical Company,** manufacturers of ferro-alloys and pure metals, have rebuilt the burned part of their works at Primos, which is now again in full operation. The new plant is entirely built of brick and iron and is fireproof.

The **Prest-O-Lite Company,** Indianapolis, Ind., for their new plant now building, have placed contract with Rockwell Furnace Company, New York, for a complete installation of oil-fired furnaces and ovens. The furnaces are the Rock-

well over-fired accurate temperature type, and will be used for heat treatment. The ovens, car type, will be used for baking asbestos disks. The installation, a large one, will have a capacity of heat treating 1200 tanks a day.

Wilfley Table.—We have received from the Mine and Smelter Supply Company, of Denver, Col., their illustrated Bulletin No. 25, on the No. 6 Wilfley concentrator. After a general description of the Wilfley table, with special reference to the improvements embraced in the No. 6 type, the methods of erecting and operating the table are described in some detail and the fundamental principles of the table are explained.

The **Titanium Alloy Manufacturing Company** has removed their general sales department to their works at Niagara Falls, N. Y., where their electric furnace plant is located, and has created a district office at Pittsburgh, where the usual work with the iron and steel trade will be continued.

The **Crucible Steel Company of America** has bought, according to the Syracuse "Post Standard," fifty acres of land adjoining the site of the Halcomb Steel Company. The next directors' meeting is expected to decide to move the Sanderson Works from their present place to this new location. There are shipping facilities on the Lackawanna Railroad and by water.

The Denver Fire Clay Company, Denver, Colo., has just issued its 1913 catalogue of assayers' and chemists supplies. The book is cloth-bound, contains 530 pages and numerous illustrations, and is more elaborate than any catalogue yet issued by the company. The contents are classified under five heads: assayers' and chemists' laboratory supplies, such as balances, crushing and grinding machinery, furnaces and general apparatus; estimates on equipment for assayers', prospectors', school laboratories; fire-clay, brick and tile; scientific books, and chemicals and reagents. A complete index renders the catalogue useful.

Digest of Electrochemical U. S. Patents

Prior to 1903.

Arranged according to subject matter and in chronological order.

Compiled by Byrnes, Townsend & Brickenstein, Patent Lawyers, National Union Building, Washington, D. C.

ORE TREATMENT (*Continued*).

605,835, June 21, 1898, Emile Andreoli and Gabriel Andreoli, of London, England.

Relates to the formation of an amalgam from a concentrated chloride of sodium solution, and the coating of copper or other metal plates with mercury electrolytically so as to render them available for the recovery of gold or silver by amalgamation, or in the mortar mill where the auriferous ores are crushed.

The apparatus consists of an electrolyzer and of an amalgamator similar to the electrolyzer. The electrolyzer is of slate or earthenware, etc., and is divided by a suitable diaphragm into anode and cathode compartments. The anode is of iron or other suitable material, and the cathode of mercury. The anode compartment contains the sodium chloride, the cathode compartment being filled with water. The sodium amalgam is tapped from the electrolyzer to the amalgamator and replaced by fresh mercury, fresh sodium chloride being added to the anode compartment. In the amalgamator the copper or other plate is coated with amalgam; the latter may if desired be continually enriched by the electrolysis of sodium chloride; or the preliminary process in the electrolyzer may be omitted, the entire process being carried on in the amalgamator. The cathode compartment of the latter contains a central shelf of inert material, leaving a narrow space along the side of the diaphragm, thereby economizing in mercury. The copper plate is laid on this shelf and covered with a layer of mercury or dipped down in the narrow vertical space at the side of the diaphragm.

614,572, Nov. 22, 1898, Joseph G. McNulty, of New York, N. Y.

Relates to a method and apparatus for treating ore. The apparatus consists of one or more pairs of tanks in which are suspended electrodes and through which flows a stream of finely divided ore held in suspension, as a pulp, in an electrolyte. The anodes are preferably of lead, the cathodes of amalgamated copper. The pulp flows in at the bottom and upwards through the first tank, and down through the second, the electrodes vibrating transversely in the flowing stream. The free metallic precious metal is amalgamated on the cathodes, and any dissolved metal electrolytically precipitated. The electrodes are vibrated "broadside"' by a rotating cam above the tanks, which moves the support for the suspended plates.

616,891, Jan. 3, 1899, George D. Burton, of Boston, Massachusetts.

Relates to apparatus for treating metals and ores, and consists of a tank containing a plurality of superimposed perforated deflecting plates immersed in an electrolyte, which distribute the ore, etc., in fine streams, and facilitate its solution in the electrolyte. At the bottom of the tank is a moving belt carrying buckets which collect the sand, etc., falling through the electrolyte, and carry it out of the solution. The electrolyte is in constant circulation. Electrodes are placed on opposite vertical sides of the deflector plates; the latter being connected to the cathode.

With copper ore, an electrolyte of sulphuric acid is used; the ore is fed to the immersed screens or deflectors, the copper dissolved by the acid and deposited upon the cathodes, the insoluble residue passing through the perforations and settling upon the traveling belt which carries it out of the tank.

617,512, Jan. 10, 1899, Lewis E. Porter, of Los Angeles, California, assignor to The Porter Gold and Silver Extraction Company, of California.

Relates to apparatus for extracting precious metals from ores, and consists of a rotating barrel supported upon a hollow shaft, the shaft carrying anodes and cathodes, the latter suitably covered with canvas, etc. Within the tank, next to the wall, are several layers of coarse and fine wire screen, and between them in the center, a layer of asbestos or other filtering material; the two outermost layers being of coarse wire. The barrel may be rotated at high and low speeds; when rotating at a high speed, it acts as a centrifugal filter, the liquid filtering off through the asbestos and out of suitable openings. The solution may consist of water containing enough sodium chloride to give it conductivity, from about ¼ to 3 per cent; cyanide of potash, ¼ of 1 per cent; and enough caustic soda to neutralize any acid in the ore. About 1 ton of solution will treat about 3 tons of ore. The mixed ore and solution are fed into the barrel which is rotated slowly, the current turned on, and the ore treated chemically and electrochemically, the metal being deposited on the cathode. When the process is completed, the barrel is rotated at a higher speed, and all liquid separated; water is then added through the hollow shaft, and the ore washed; additional water is now added to bring the ore to a slush, which is then removed from the tank, and a fresh charge added.

617,911, Jan. 17, 1899, Elias Anthon Smith and Markus Hartmann Lyng, of Anaconda, Mont.

Relates to a method of extracting metals from ores. A suitable rotary tank, having an acid-proof lining, is charged with copper ore, sulphuric acid and 10 to 15 per cent of manganese dioxide; the sulphuric acid being present in sufficient quantity to convert the metals, including manganese, to sulphate, with a slight excess. The tank is rotated slowly, and hot air from 40 to 80 lb. per square inch pressure is pumped in the tank. The metals present, except gold, are converted into sulphates, the action continuing from 4 to 16 hours. The solution is drained off, settled, and the clear solution run over copper filings to pre-

cipitate any silver; the remaining solution is electrolyzed, separating copper at the cathode and manganese dioxide at the anode. The remaining electrolyte is evaporated to crystallize out any copper sulphate or manganese sulphate, the sulphuric acid remaining being now in condition for re-use in the digester with fresh ore. If gold is present, the tailings from the the first treatment are digested a second time with manganese dioxide and hydrochloric acid, the chloride of the gold being recovered and treated as usual.

BOOK REVIEWS.

Lehrbuch der Chemischen Technologie und Metallurgie. Edited by Dr. Bernhard Neumann, Professor in the Technical High School in Darmstadt. Large octavo, 17 x 24 cm., 891 pages, 398 illustrations. Price, 19.60 marks (in New York, $6.00). Leipzig: S. Hirzel.

This is a collection of forty-five chapters, varying in length from 2 to 100 pages, written by the editor and his 18 collaborateurs. The space is too restricted for compendious treatment of any one subject, but the style is short and condensed, and there is an immense amount of information, correct and very well brought up to date, within the covers of this book. The topics are: Water, Liquid Air and Compressed Gases, Combustibles, Illuminating Gas, Coke, Turf, Charcoal, Salt, Potash Salts, Sulphuric Acid, Hydrochloric Acid, Nitric Acid, Hydrofluoric and Phosphoric Acids, Soda, Electrolytic Alkali, Ammonia and Cyanides, Alumina, Aluminum and Ultra-Marine, Magnesium, Calcium and Barium Compounds, Per-oxides and Per-salts, Fertilizers, Cements, Stoneware, Glass, Iron, Other Metals, Explosives, Mineral Oil, Asphalt, Mineral Wax, Distillation of Tar, Acetic Acid, Methyl Alcohol and Acetone, Fats and Soaps, Rubber, Glue, Tanning, Beet Sugar, Starch, Fermentation, Wine, Beer, Spirits, Cellulose and Artificial Silk, Textiles, Dyes, Dyeing. The work is a splendid reference book for these subjects, for students, engineers or manufacturers.

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Cast Iron, in the Light of Recent Research. By W. H. Hatfield. Octavo, 16 x 22½ cm., 249 pages, 164 illustrations, including many microphotographs. Price $3.50. London: Chas. Griffin & Co., Ltd. Philadelphia: J. B. Lippincott Co.

This should be a very useful book to the worker in cast iron and users of the same. Separate chapters treat on the influence of silicon, phosphorous, sulphur, manganese, and other elements. Other chapters handle casting temperature, shrinkage, growth by repeated heatings, effect of superheated steam, heat treatment, decarburization, malleable cast iron, furnaces and slags, and the mechanical properties and testing. The author's discussion of the malleablizing process is interesting. His investigations support Ledebur's original theory and negative Wüst's conclusions. It is a cleancut, practical and commendable treatise.

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The Metallography of Iron and Steel. By **Albert Sauveur.** 7 x 10½ in. (17¾ x 27 cm.), perhaps 280 pages, doubtless over 300 illustrations, plate paper throughout; price $6.00 net. Cambridge, Mass.: Sauveur and Boylston.

The contents comprise a chapter of thirty-five pages on apparatus for the metallographic laboratory, thirty-four "Lessons," of eight to thirty pages length, each paged separately, one appendix on "Manipulations" and another on "Nomenclature."

The separate paging of each lesson, and separate numbering of the illustrations in each, made it impracticable for the reviewer to state the number of pages or of illustrations in the book. Others besides the reviewer are going to find inconvenience in this unusual arrangement; any reference to data in the book will have to comprise both "Lesson" and page. The consecutive numbering of the pages and illustrations in the next edition will cost the publishers a few dollars extra, but it is a false economy not to make the outlay.

As for the book itself, it is very satisfactory. The illustrations are fine, and beautifully set off on the smooth calendered paper. The text is clear and definite, giving the beginner sure and sound foundation stones on which to build securely his subsequent work. In this respect it is the best text on metallography for beginners, and the clearest guide to further study, that we have seen. The auxiliary metallurgical information is unusually lucid and well-classified.

We are glad to commend the work highly to students of metallography.

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Introduction à l'Etude de la Metallurgie. Part I: Le Chauffage Industriel. By **Henry Le Chatelier.** 16 x 24 centimeters, 528 pages, 96 illustrations; price 12 francs, bound, 15.50. Paris: H. Dunod and E. Pinat.

The ten chapters deal with: Industrial Science, Phenomena of Combustion, Calorific Efficiency, Natural Fuels, Charcoal and Coke, Acetylene and Water Gas, Illuminating Gas, Producer Gas, Refractory Materials, Furnaces. Part II, dealing with metals and alloys, will constitute a separate volume.

The preface strikes the keynote of the work, saying: "The teaching in our higher technical schools ought to become scientific, and should no longer content itself with being simply professional." Following this idea, the whole of this work is concerned with the why and wherefore, the scientific explanation, of heating and combustion, with only sufficient description to serve as a skeleton or framework for the discussions of principles.

This method is the best possible, provided it is supplemented by lectures which put spice into and give zest to the subject. Professor Le Chatelier, with his rich supply of specimens, models, pictures and diagrams, no doubt makes the subject-matter of the book highly attractive; but the book would be dry work for the student without some such illustration. Furthermore, while the work may be suited to French students and teachers, we doubt its usefulness outside of this limited circle, except to a few specialists in combustion. The latter will find in it useful ideas on the nature of flame and the propagation of combustion.

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Volume II of the Annual Tables of Constants and Numerical Data, Chemical, Physical and Technological, edited and published by an International Commission created by the Seventh International Congress of Applied Chemistry and continued by the Eighth Congress, is now in press and will be issued about January 1, 1913. Volume I, which was issued early this year, was sold to subscribers at $5.00 (unbound). The volume proved to be about 50 per cent larger than the International Commission had anticipated. The second volume will have to be issued at a somewhat higher price, the exact amount of which has not yet been determined upon. *Subscribers* to the second volume, whose subscriptions are received before January 1 by Dr. Charles Marie, secretary of the Commission, 9 rue des Bagneux, Paris, France, or by the University of Chicago Press, Chicago, American Publishers, will be entitled to receive the volume at the price at which it is issued to subscribers and will have the right to cancel their subscriptions within four weeks after the price is announced. Subscriptions should therefore be sent at once. Payment of the subscription will be made to the University of Chicago Press, when the volume is published. The price of the volume will be materially higher for non-subscribers, as only a limited number of copies beyond those subscribed for will be printed. Further information may be secured from the above addresses or from any one of the American Commissioners, Dr. Julius Stieglitz, University of Chicago, Dr. E. C. Franklin, Bureau of Hygiene, Washington, D. C., G. F. Hull, Dartmouth College, Hanover, N. H.